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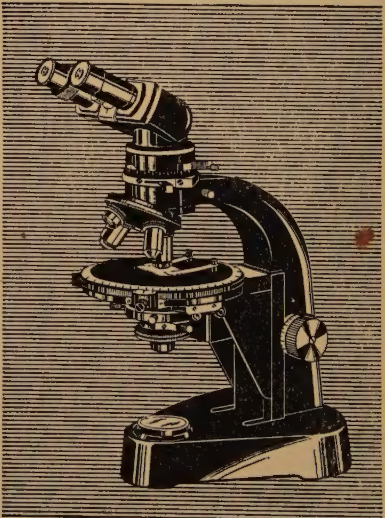

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GEOLOGISKA FÖRENINGENS
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No 507
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The Middle-Swedish Moraines in the Province of Dalsland, W Sweden

By

GUNNAR GILLBERG

ABSTRACT

The large marginal deposits, situated in western Sweden between Lake Venern and e Norwegian border were formed during the stagnation period of Younger Dryas time s a part of the Fennoscandian moraines. Especially the northern belts — the end moaines on the Dalbo plain and the large glacial complexes W. of Kroppefjäll — are discussed in detail.

Except at Ödsköld, thrust moraines seem to be very rare. Dump moraines occur more ften but are usually of small extent. The form (dune-like) and the composition (dense nd compact till with foliation or similar structures) of the large terminal ridges seem indicate a subglacial, gradual accretion of drift by a flowing and pressing ice margin. hese end moraines may be characterized as lodge moraines. But the real, terminal lodgent has apparently occurred only towards and upon a primary foundation of till (small ush or dump moraines), glaciofluvial accumulations or small rocks.

Also the Marine Limit is discussed, especially as an important element for analysing e deglaciation and for determining the timedifferences between separate terminal rms.

All variations in the ice movements, the position of the ice margin, the forming of ifferent terminal elements etc. have mainly been due to varied topographical conditions the separate areas and in the back-ground.

The large moraines are often divided into separate parts, indicating a subdivision the stagnation period into different stagnation and recession phases. Four such stagation phases have obviously occurred, of which the initial and culmination phases have en divided into two and three subphases, respectively.

Preface

The Middle-Swedish morainic system W. of Lake Venern is approximatel identified as to its position and extent but its different forms have only incidentally been mentioned in the descriptions of certain geological maps (Törnebohm 1870, De Geer 1902, 1910, Svedmark 1902). An exception is the central comple at Dals Ed which is analysed by De Geer (1909). But also the other termina forms here deserve a detailed description. This applies in particular to the complex at Ödsköld which may be one of the most extraordinary glacial formation in Sweden.

The drift borders on the Dalbo plain

On the Dalbo plain between Lake Venern and Kroppefjäll there are tw distinct belts of end moraines (fig. 1). In the area between them no typica terminal elements seem to occur. Locally, till certainly projects through the Late- and Post-Glacial sediments but these occurrences are probably only outcrops o the general ground moraine. However, two of these localities may be termina deposits. At Erikstad small rocks are the prominent features but they are covere by relatively thick till, especially on the proximal side. In some places, a rea morainic distal slope is developed, and then the whole locality resembles an en moraine, as seen from the South. Also at the southern end of Lake Örsjön til covers the valley side in such large quantities and is so located that presumabl it is of terminal origin.

Such ridge-like till concentrations on rocks or close to valley slopes can perhap be interpreted as being a transition form to real end moraines or as a specia terminal element (cf Björsjö 1948). Whichever explanation is the right one, thei shape and composition form such a decided contrast to the real end moraines that it seems best to introduce a special term. As rocks are integral parts of them and have been the basis for the deposition, I suggest the term "rock (end) moraine" (Swedish: hällmorän). They are probably common (Björsjö 1949) bu often it may be difficult to identify them clearly.

The Gestad-Tåsterud moraine (fig. 1)[1]. In the southern drif border the end moraines at Gestad are very moderate both in length and i breadth, and connected with small rocks at least at one short side. They rise onl ½—1 m. above the surrounding sediments but, as they are strongly abraded, the may originally have had a larger extent.

At Brålanda the drift border is multiple (perhaps two main lines), includin at least five end moraines. These are more differentiated and apparently n connected with rocks. The distal sides are relatively steep, the proximal ones mor sloping. The northern ridges have high central crests, distally displaced.

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[1] The term moraine together with a place-name is used as a synonym to a morainic belt or dri border. When speaking about a special element, the term end moraine, ridge or the like is use

The three end moraines at Tåsterud are from all points the ones best developed nd rise 3—4 m. (sometimes 6 m.) above the Late- and Post-Glacial sediments. The surfaces are more or less plane-abraded. The uppermost till is usually redeposited as wave-rolled gravel but large residual boulders remain. The proximal ides are steeper near the short sides, the distal ones in the central parts. All the idges have a composite form, two longitudinal crests thus being developed. That will in all probability denote a slow but continuous deposition with two more ctive phases. Presumably these latter stages of development correspond to the orming of the southern and the northern ridges åt Brålanda, respectively.

Only a few shallow sections, with till, are found. The boulders are mainly rientated in the direction of the ice movement. Thrust features have not been ound. All the end moraines may accordingly be interpreted as depositional idges.

Glaciofluvial material is not entirely lacking in this drift border. Along Kroppejäll which at this time may have been almost ice free, meltwater has occurred n greater quantities, perhaps owing to the vicinity of a warm valley side. There-ore subglacial streams have been active, periodically, and stratified drift has been ccumulated in the form of small esker hills right up to Lake Örsjön. Higher up n the slope of Kroppefjäll a real outwash-delta has also developed. It reaches he Marine Limit and consists of predominating gravel and well-rounded stones. The finer material has been deposited further down on the Dalbo plain. Towards he apex, five glacial stream channels occur on a till-covered height behind. They re ½—1 m. deep and particularly at the bottom they are very rich in boulders nd stones. Also the bedrock has been eroded. The outwash-delta has accordingly een built up outside an ice lobe on the slope of Kroppefjäll and not at the argin of the large ice on the Dalbo plain.

The Järn-Mellerud moraine (fig. 1). The northern drift border egins in the East with an end moraine, extended over one mile and divided into hree parts.

The characteristic form of the wall at Hjortens udde is due to its very exposed osition in Lake Venern. The abrasion has certainly not only sharpened the ridge ut also reduced its height to about 10 m. The form is therefore sharp-edged and he distal side is nearly precipitous. Most of the finer superficial material has een washed away and mostly been redeposited proximally[1]. By wave and wind ction it has then changed into drift-sand which now partly covers the lower part f the proximal slope.

The rest of the eastern ridge is broader but still relatively steep. It attains a eight of about 21 m. above Lake Venern. Owing to the high position of the ediments S. of the wall, only the uppermost part of the distal side is visible about 5 m.). On that account the rounded crest seems to lie distally, although

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This distribution of the redeposited material may indicate dominating winds from the South-outhwest during Post-Glacial time.

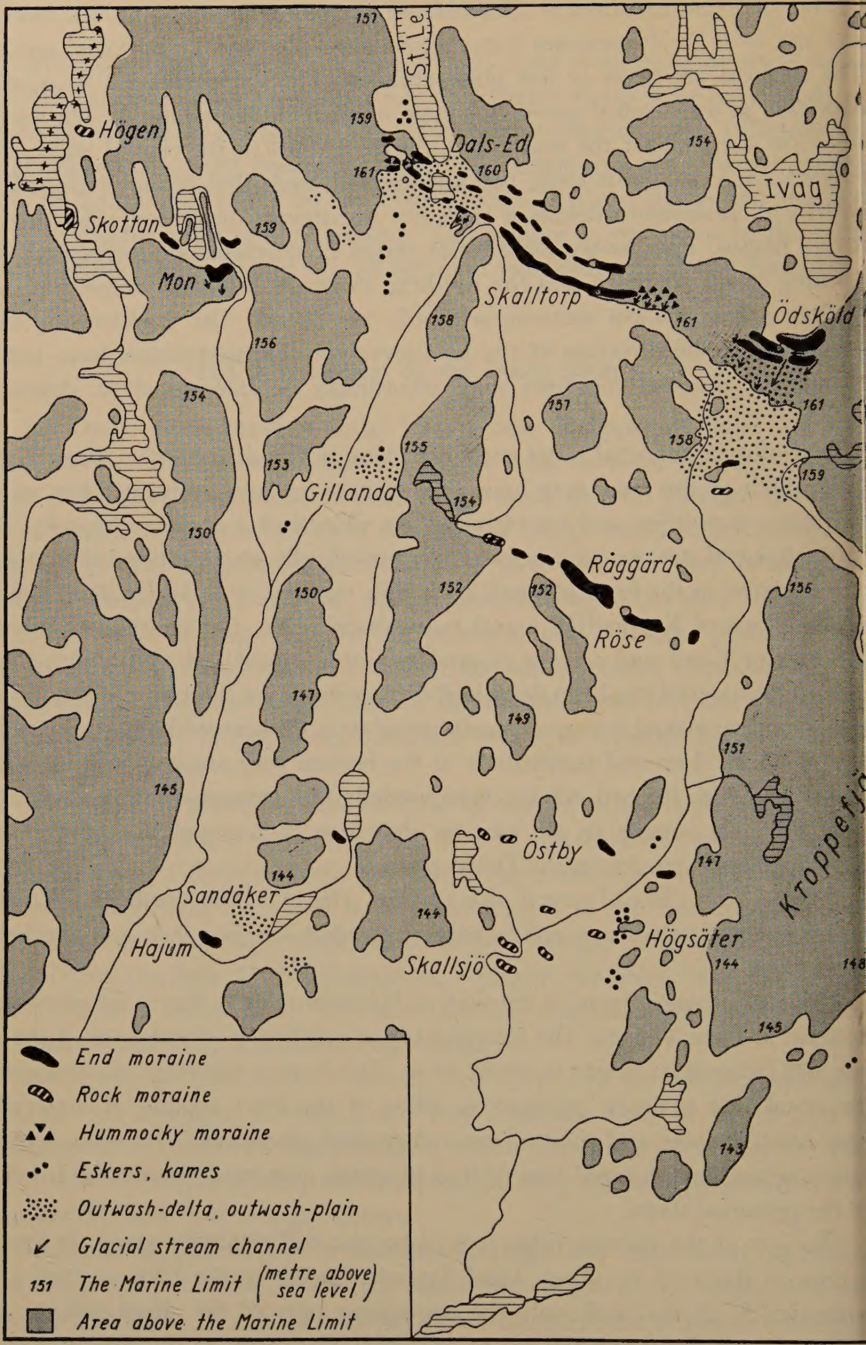
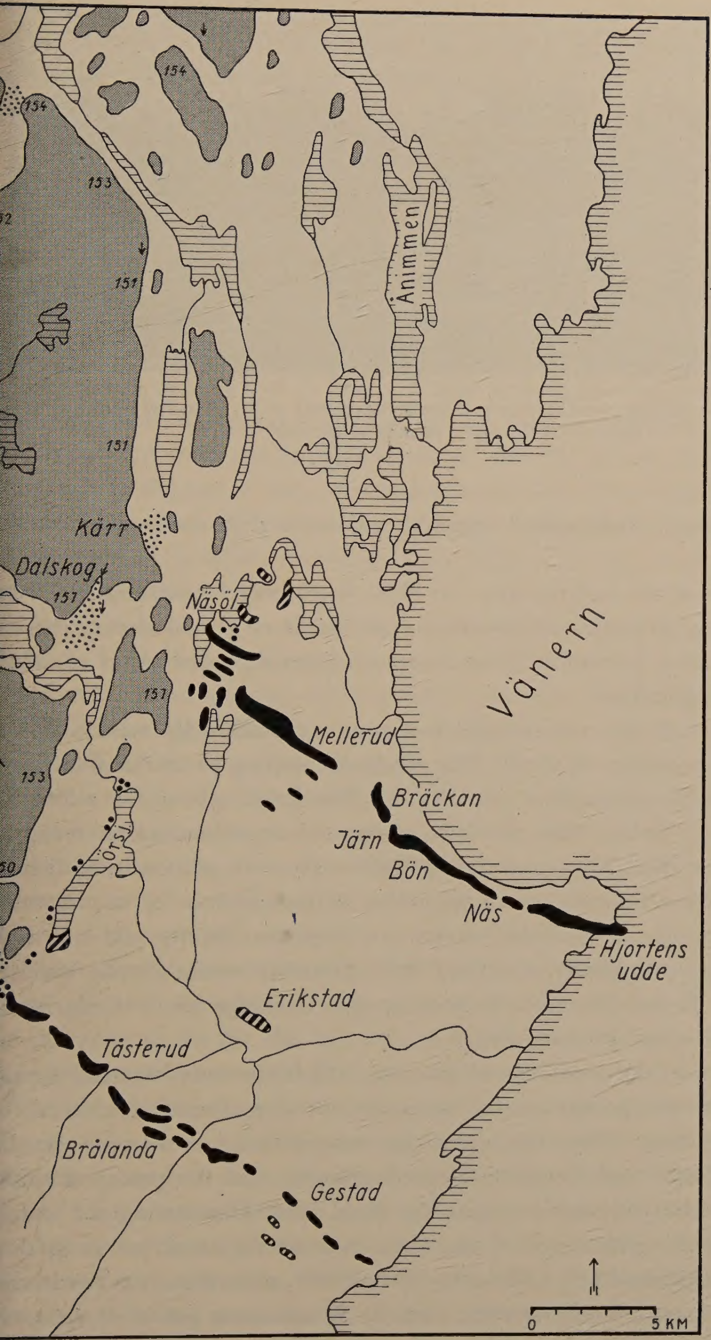


Fig. 1. The Middle-Swedish morainic syste



the province of Dalsland.

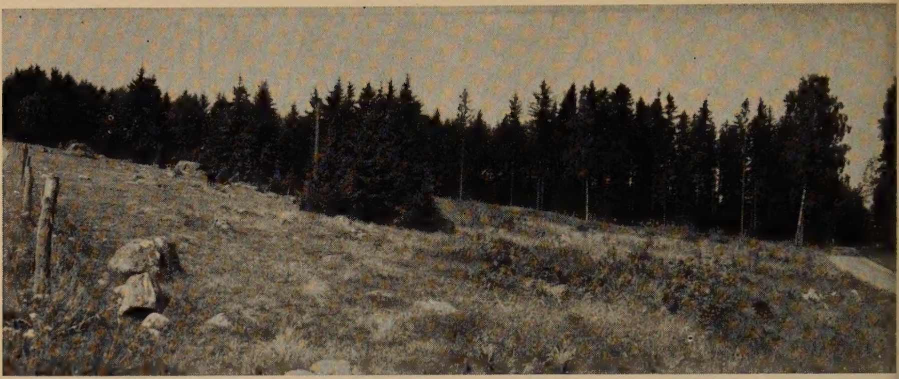


Fig. 2. The gradually sloping, proximal side of the western part of the Järn end moraine. The distal crest lies quite outside to the left.

it is centrally situated. Redeposited material and some drift-sand occur on the proximal side.

The middle part of the end moraine (at Näs) is scarcely 1 km. long and 2 m. high. That seems to be a primary feature, for no marks of glacial stream erosion or subsequent abrasion are visible. From various causes the production of debris has been inconsiderable here.

The western part of the end moraine begins as a typical ridge with a sharp-edged crest, lying prominently distal. The gradually sloping proximal side forms a sharp contrast to the steep distal side (fig. 2). The height above the sediments is 6—7 m. (at Bön). To the West, the form of the end moraine changes abruptly. The breadth is more than 70 m. and the surface is very even without any distinct crest. The distal side resembles here a secondary deformed slope of an outwash-delta. Furthermore, as well-rounded stones are common distally and morainic boulders occur only proximally, stratified drift probably exists distally and towards the bottom. It may therefore be possible that the ridge has a similar composition to the following Bräckan wall.

Apart from here in the western end moraine, till is the only material found. Unfortunately, however, no sections are accessible but several test-holes have been made (about 1 m. deep). Only the superficial composition can therefore be discussed in detail. Dense and compact till predominates, and the proximal slopes are considerably richer in boulders than the distal ones. Concerning the organization of stones and boulders, which can often indicate the construction method of end moraines (Holmes 1941, Lundqvist 1948, 1949), an orientation perdendicular to the ridges is entirely dominating (fig. 7). From many points of view, the wall at Hjortens udde is an exception. The till is of looser composition, and boulders occur in considerably greater quantities (also distally) and have a more variable orientation (fig. 7). On the whole, these circumstances may be primary

acts but to a certain degree they may be due to the radical destruction of the
idge (cf above). A re-arranging of the boulder material by waves and sliding
ea-ice might have occurred, for instance.

Owing to these variations in form and composition, it is difficult to give a clear
nterpretation of the development of the Järn end moraine. The whole ridge
eing really topographical controlled as to its position, has possible been one
ause of the vary changing accumulation here. It is built up at (or towards) the
nargin of the Archaean peneplain where the latter descends towards NW into
he depression of Lake Venern outside the shore between Järn and Hjortens udde
fig. 1). Just in such a position, the conditions at the ice terminus might rapidly
ave changed character, resulting in a disparate and heterogeneous terminal de-
osition, both in time and in place. Thrust actions may have occurred as well as
umping. This applies in particular to the wall at Hjortens udde, where both
hese processes must not be underrated as possible factors in the terminal accu-
nulation. As the rest of the end moraine is situated on the uphill of the real pene-
lain, a deposition by continuous lodgment might also have occurred. Such a
onstruction is possible, especially with respects to the form and the boulder
rientation of the western ridge.

The next part of the drift border is a broad, top-abraded wall at Bräckan.
ontrary to the other end moraines here, it has a nearly North-South extension.
he distal, i.e. the western, side is partly a secondary deformed slope, rising about
—7 m. above the sediments. A large distal section shows dense and compact till
a depth of 2—3 m. Locally, a bedding-like structure conformable with the
rface is visible (fig. 3), probably indicating a deposition under high pressure.
oulders have a preferred orientation in a NE.-SW. direction, i.e. not perpendic-
larly but at a comparatively oblique angle to the long-axis of the wall. In the
uthern part of the section, till covers a pocket of horizontal sand, overlying a
yer of well-rounded stones. The construction of this wall has obviously begun
ith an accumulation of stratified drift; then the till has been supplied from NE.
s the glaciofluvial material seems to be disturbed only a little and in regards to
e character of the till, the latter has probably been deposited subglacially under
igh pressure from overriding ice and not by thrust movements.

The discrepancy as to form, composition and origin of the Bräckan wall may
ctually have been caused by a change in topographical conditions. Just here the
rchaean peneplain descends into the depression of Lake Venern. That has made
e ice bend southwards and reach a more southerly position in this area, thus
rming to the West a terminus of an almost N.-S. direction. Appearing ice actions
ave therefore partly been directed towards SW., i.e. towards the margin of the
eneplain. On that account, ice tensions have probably been common, resulting
a forming of crevasses and tunnels and so, periodically, occurrence of melt-
ater and an accumulation of glaciofluvial material.

Right in the middle of the Dalbo plain, the end moraine at Mellerud is situ-

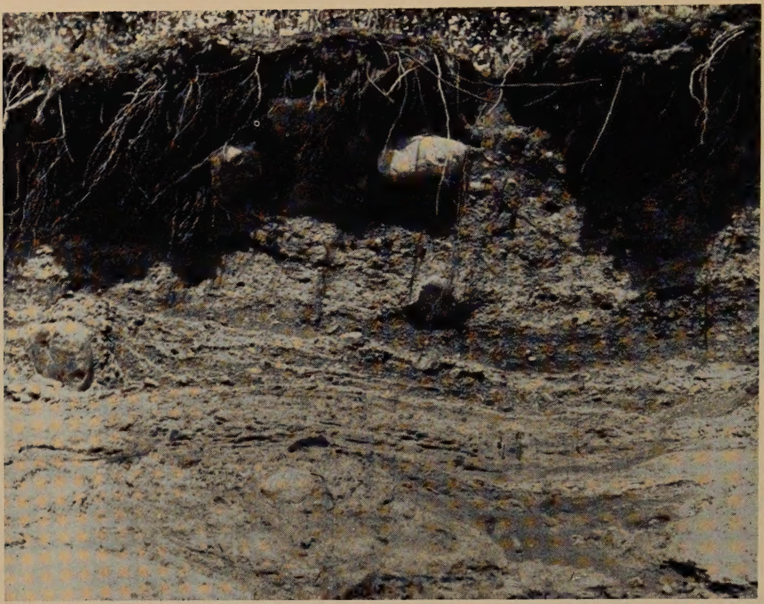


Fig. 3. Section through the Bräckan end moraine. Dense and compact till with a bedding-like structure, probably formed during a continuous lodgment by overriding ice. The ice movement towards the reader.

ated. The eastern part is sharp-edged with a marked crest near the distal side (about 5 m. above the sediments). The proximal slope is very stony and rich in boulders. The till is dense and compact and the boulders have a preferred orientation perpendicular to the wall (fig. 6). Distally and towards the bottom, however, a comparatively large percentage of the boulders lies parallel to the ridge. This composition may indicate a lodging addition of debris towards and upon a primary foundation, probably pushed up. Such a development is also shown by the form, the end moraine having a short and steep distal side and a gradually sloping proximal side.

The middle part of the Mellerud ridge is broader and plane-abraded with only a rest of a distal crest. Essentially, it has a similar composition to the eastern wall but the sloping proximal side is at the basis resolved into shallow kettles and small mounds of looser till, rich in boulders. Here, too, the development will probably have begun with an active phase. Then the ice terminus seems to have begun to break up, perhaps owing to the occurrence of projecting rocks. A concluding deposition by dumping might therefore have been determining for the construction of the irregular proximal slope.

The western part which has a similar form to the middle wall, consists mostly of gravel (at least to a depth of 2 m.). This is probably glaciofluvial material which, as regards the boulder orientation, must have been accumulated by meltwater streaming along the ice margin (Lundqvist 1948).

To the West, the drift border concludes with a series of small end moraines. Following the Mellerud wall there are three, somewhat longish hills (in the direction of the ice movement) with channel-like gaps between them and along the inner side towards the western plateau. The two western hills may partly consist of stratified drift, as well-rounded stones are visible here and there in ditches. Till predominates superficially, however, and therefore the hills have been characterized as end moraines on the map. The interjacent depressions decline southwards and have probably been used by (sub)glacial streams[1]. No distinct marks of glaciofluvial drainage are visible, however, possible owing to a levelling of the ground by covering sediments and cultivation. But several circumstances seem to indicate the occurence of meltwater. Stratified drift in form of eskers and kames appears locally along the western plateau right up from the southern drift border and also N. from here. To the East, gravel of similar kind is found in the western part of the Mellerud ridge. And, furthermore, glaciofluvial fine sediments occur outside the hills. Here, there may also have existed many favourable conditions for generation of subglacial streams. The vicinity of an ice-free plateau has certainly caused an increased wastage. And Lake Näsöl presumably lies in a small rock depression which has served as a gathering channel for the meltwater.

Quite behind the three outer hills there follows three small end moraines and one large ridge. They have all irregular form with steep sides and undulated surfaces. The till is of looser composition and comparatively rich in boulders. All these features may indicate, the ridges being dump moraines. Owing to differences in extension, form and position, the three middle ridges seem to form a unit between the distal hills and the proximal wall. The Näsöl end moraines may therefore indicate three stages of the stagnation phase.

This multiple and partly disparate configuration of this locality forms a sharp contrast to the great uniformity of the ridges at Järn and Mellerud. Probably that is due to the whole complex having unmistakably developed in a small calving-bay. All the features, which ought to characterize such an area of deglaciation, are found. One or several subglacial streams have had their mouths here with periodical accumulations. And to the East, the adjoining end moraine at Mellerud has an oblique course towards the Näsöl depression. Owing to the appearance of a long stagnation phase, the development of the calving-bay was nterrupted, however, and end moraines were built up instead of glaciofluvial accumulations. But periodically during this time, the wastage could more in-ensely assert itself and several short recessions occurred. The retreat of the ice

A reverse development cannot be precluded. In such a case, the hills are accumulated in or utside subglacial tunnels, i. e. they are esker hills with till only on the surfaces, and the depres-ions between them were filled with ice instead of meltwater. Whichever explanation is the right ne, the development must, for the rest, have followed the description above.

margin to new positions has certainly been due to an increased calving (cf Hoppe 1948).

The Dalskog outwash-delta (fig. 1). On the plateau W. of the Dalbo plain an outwash-delta has developed at Dalskog. As it follows almost directly on the Järn-Mellerud moraine and the main border W. of Kroppefjäll, it was evidently built up during the same stagnation. Its position, however, is definitely controlled by topographical conditions. It lies in the innermost part of an ancient cove of the Late-Glacial Sea, and in that very position, i.e. where supra-aquatic terrain began, stagnations have often occurred owing to a change in balance between the thinning and the calving (Gillberg 1956). As it appears from the height of the Marine Limit and from the different positions of the drift borders E. and W. of Kroppefjäll, the narrow passage outside this locality has only been in open communication with the Sea to the West. Its eastern mouth was closed by the ice on the Dalbo plain, reaching down to the Näsöl-Mellerud border line.

Only a distal, irregular slope is developed, for the rest the delta is bounded by plateaus. Proximally the plane is even and reaches the Marine Limit. Between the delta and the surrounding heights, shallow meltwater channels are visible. Also downwards to the apex, marginal stream terraces and proglacial channels are found. The accumulation has accordingly occurred from an overhanging ice lobe on the plateau N. from here.

Terminal forms N. of the Mellerud end moraine (fig. 1). Proximally of the Näsöl ridges, there is mostly a terrain of rock outcrops but some ridge-like concentrations of till occur. However, these will scarcely be remains of a larger crescentic end moraine but are rather isolated, lateral "rock moraines", built up outside a lobated ice margin.

A small outwash-delta at Kärr is an approximately synchronous accumulation. The distal side is secondary deformed, the proximal one has ice-contact features. The material is mostly coarse gravel and well-rounded stones, but fine glaciofluvial sediments occur along the valley side both distally and proximally.

As to their position, these terminal elements would belong to the northern moraine on the Dalbo plain. As it appears from the height of the Marine Limit, however, they must be essentially younger, formed during a later stagnation of short duration before the definitive recession northwards (cf page 363).

The drift borders W. of Kroppefjäll

Contrary to the even Dalbo plain, the terrain W. of Kroppefjäll is very broken and characterized by narrow, N.—S. valleys and between them rock plateaus of varying extent. The valleys are more or less filled with Late-Glacial fine sediments which, however, reach the Marine Limit more seldom. Projecting rocks (with or without till) are common. On the slopes of the plateaus, till predominates.

Owing to this broken terrain, it is often difficult to carry out a comprehensive ınd detailed analysis of different terminal forms. Small and incompletely devel- ɔped elements can be disregarded. Terminal deposits without pronounced form nay certainly occur in larger quantities than can possibly be determined off ıand. Small end moraines can also exist at the valley bottoms but be covered by ine sediments. The valley S. of Dals Ed, for instance, is locally often characterized ɔy transverse undulations which may be due to existing end moraines.

Three drift borders can be distinguished, however, The northern one is very narked and constitutes the predominating feature of the lanscape.

The Högsäter-Hajum moraine (fig. 1). The southern drift border ɔegins at Högsäter with three big hills of glaciofluvial material. They lie on distal ɔr proximal sides of supermarine heights. As regards their form and material (bedded coarse gravel and well-rounded stones), they may be characterized as ɛsker hills. The two northern ones, however, resemble small outwash-deltas, hav- ng partly even surfaces and reaching nearly the Marine Limit.

Westwards, the drift belt continues with several small "rock moraines" between Skallsjö and Östby. They are somewhat crescentic and protrude from the valley lopes. Evidently they were built up outside an ice lobe in the Valbo valley and hey are certainly of depositional origin.

At Sandåker there follows a large outwash-delta. The proximal side is steep vith partly ice-contact features, and also the distal side is mainly preserved in ɔrimary form. The surface, which lies about 20 m. below the Marine Limit, is ɔlane-abraded and partly covered with redeposited wave-rolled gravel. Shallow ɛettles are still visible, however. A distal section shows inclined and cross-bedded ayers of varying grain size. Folding and irregular contortion also occur, indicating ome pressure of the accumulating ice lobe.

The only typical end moraine of this drift border is found at Hajum in the Örekil valley. It is a somewhat crescentic, big wall with steep distal side. The ɔroximal one is more sloping. A large section shows partly disturbed stratified lrift with proximal overlying, dense and compact till with a boulder orientation ɔerpendicular to the ridge. This construction certainly indicate a subglacial de- ɔosition of till by an active flowing ice lobe.

Although these terminal forms lie very sporadically, they may constitute a real lrift border, to the East obviously divided into a southern and a northern belt. ıs it appears from the height of the Marine Limit, it is equivalent to the southern ıorainic belt on the Dalbo plain but, as opposed to that, lies more southerly and ıas a more E.-W. extension. It is furthermore discontinuous, being composed of ɛparate elements in different valleys. Only in the broad Örekil valley a more fficient ice activity seems to have occurred, for the rest ice movements have been f secondary importance. This development was probably due to the ice here aving entered a dissected landscape after the recession over lower terrain in the

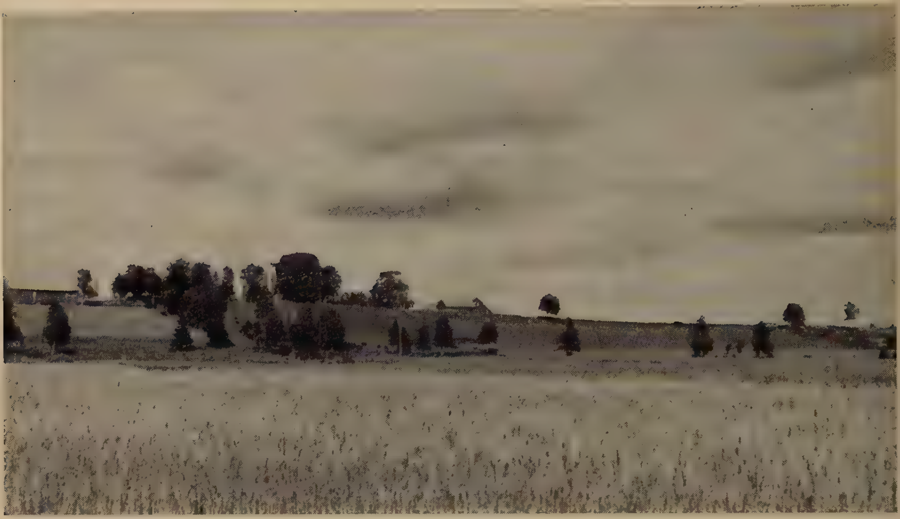


Fig. 4. The Röse end moraine. The crest and the distal slope.

district of Bohuslän. By this the ice margin has been lobated, and furthermore this topography has determined the position and the form of the terminal deposits.

Towards W.-NW., the drift border possibly continues with the large outwash-delta and appendant end moraines at Lake Bullaren.

The Röse-Gillanda moraine (fig. 1). The middle drift border begins in the East with a drumlinoidal hill. Then follows the somewhat crescentic end moraine at Röse which is connected with rocks at both the short sides. The proximal side is steep, the distal one is usually a secondary deformed slope (fig. 4). The surface is relatively plane-abraded and lies a few metres below the Marine Limit. The material is obviously only till, the boulders of which are mainly orientated parallel to the direction of flow.

The following end moraine at Rårggärd is nearly 2 km. long and more than 80 m. broad. The central crest projects 10 m. above the Marine Limit. The distal side is precipitous, the proximal one is more sloping. As it appears in a large section, the ridge consists of dense and compact till (fig. 5). Near the surface it is rich in stones and boulders which have a preferred orientation perpendicular to the wall (fig. 6). Locally, also a flaky structure, similar to foliation and parallel with the surface, is visible. All that seems to indicate an addition of debris by an active ice margin, probably a lodging process. But in regard to the form and the height of the ridge, real thrust movements cannot be precluded. A few well-rounded boulders have also been found near the bottom, so some stratified drift possibly occurs distally and towards the bottom.

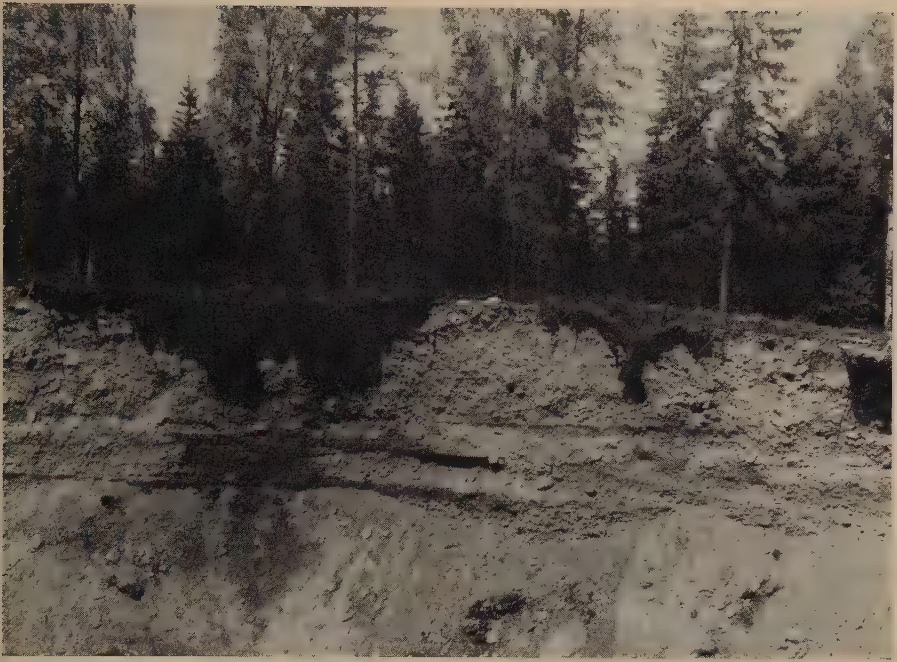


Fig. 5. Section through the Råggärd end moraine. Dense and compact till rich in boulders. A preferred orientation of the boulder material in the direction of the ice movement, i. e. from the right-hand corner, is partly visible.

Westwards there follow directly two small end moraines, in both form and composition resembling the Röse wall.

In the Örekil valley a high but narrow outwash-delta has developed at Gillanda. In the East it is connected with the valley side, westwards it abruptly descends down to the river. As the delta has a western appendage, it has the character of an extensive valley barrier. Both the distal and the proximal sides are steep. The former is partly secondarily deformed, the latter has primary ice-contact features and is followed by a small esker. The surface, which lies about 10 m. below the Marine Limit, is even but a few low erosion remains are found. The delta has therefore probably been built up nearly to the Marine Limit but owing to its exposed position has been reduced to the present height. Redeposited wave-rolled material is common both superficially and distally.

The middle drift border is accordingly a concentrated belt of prominent and uniform elements. The ice margin seems to have been divided into separate lobes between already deglaciated plateaus. On that account, it has attained different positions southwards and reacted disparately in different valleys. The form and composition of the terminal elements indicate an active ice margin in the broad Valbo valley, a stationary ice lobe in the narrow Örekil valley. Locally the terrain, also in detail, has had a determining effect on the development, that is illustrated

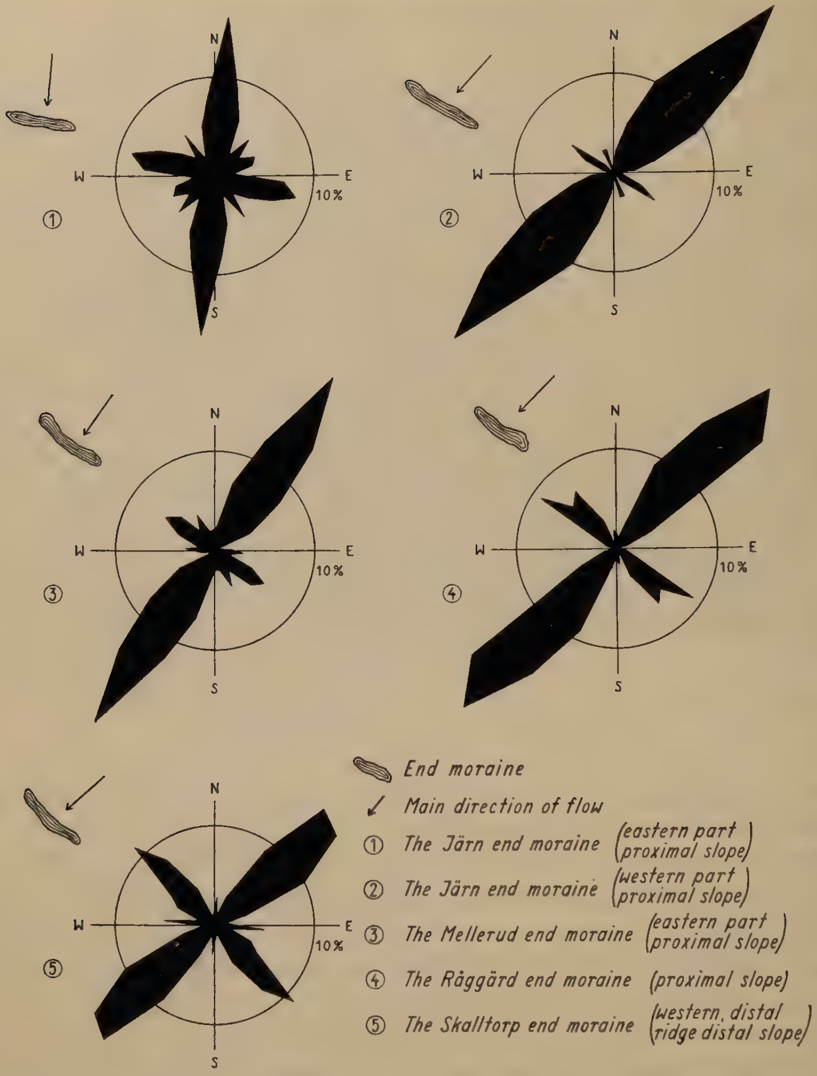


Fig. 6. The boulder orientation of five end moraines. The diagrams no. 1, 2, and 3 are from the surfaces of the ridges and are based on analyses from fives plots of 2m² in size. The diagrams no. 4 and 5 are from sections through the ridges and are based on analyses from three plots of 1 m² in size.

by the construction of the end moraines in the Valbo valley. The broadest an highest wall lies in the middle and probably deepest part of the valley, whic there is open northwards; the low ridges appear at the flanks, i.e. towards th beginning of the curving valley sides or before small, projecting supermarin heights. The ice activity has consequently been most efficient where a continuou low and transfer of debris towards the terminus was possible, considerably reduced where the friction was higher or different obstacles occurred.

Except the "rock moraines" at Erikstad and Lake Örsjön, the middle drift border has no equivalents on the Dalbo plain. Also westwards no corresponding erminal forms seem to occur.

The Ödsköld-Dals Ed moraine (fig. 1). The large complex at Ödsköld forms the eastern part of the main border (fig. 8, 9). It includes several different terminal elements which, as regards to time, correspond to three stagnation phases with a concluding ridging-up action. The complex is situated in a narrow passage of the Late-Glacial Sea. It is accordingly as to its position topographical controlled but, as to its origin, clearly the result of climatic fluctuations.

The first stagnation occurred in the mouth of the Late-Glacial passage, where two outwash-deltas have been built up like two "guardians" of the valley. The eastern delta (at Bäcke) is an isolated large hill with a rounded surface near the Marine Limit. No sections occur but as is visible superficially, glaciofluvial gravel and well-rounded stones are the predominating material. Proximally some till occurs but as no indications of ice activity are observed, it is evidently a deposit at a stationary ice margin.

The western equivalent is more composite. At Vadstena a small isolated outwash-delta is built up to the Marine Limit. It consists mainly of horizontally bedded coarse gravel and well-rounded stones but distally some layers of inclined bedded sand occur. Westwards a low end moraine leads over to the outwash-delta at Vången. The latter has an irregular surface, partly lying above the Marine Limit. Distally it is connected with a small height. The material is very heterogeneous, indicating variable drift of current and varied afflux of meltwater. Also here, till appears proximally and right up to the top (fig. 7). As the underying stratified drift does not seem to be disturbed in a higher degree, it may be deposited subglacially by an overriding or only overlying ice. Probably also the delta is (partly) accumulated in a subglacial tunnel. During the stagnation, the distally situated height must have obstructed a complete deposition outside the very mouth of the subglacial stream. On that account, the accumulation here occurred more to the sides, and the distal part of the delta has got a ridge-like hape. Finally, a proximal filling of the subglacial tunnel occurred, followed by he deposition of till.

During this stagnation two main streams of meltwater seem to have been dominating. The accumulation has therefore been more concentrated but on the other hand more variable, resulting in very heterogeneous material.

The following recession northwards was soon interrupted by a new stagnation and a new outwash-delta was built up at Kraxvad. This delta which to the NW. s connected with small heights, has a steep distal side and a relatively even surace near the Marine Limit. A proximal section shows a topset bed of horizontally bedded gravel and badly sorted and slightly rounded stones and boulders. It

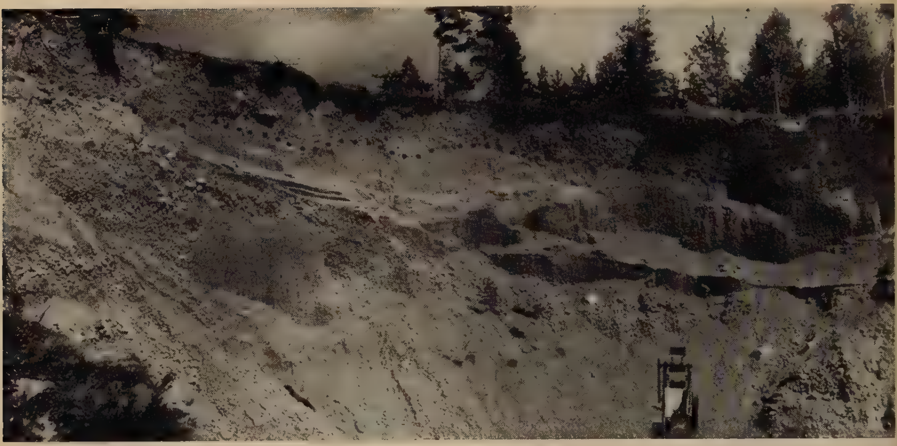


Fig. 7. Section through the outwash-delta at Vången. Varied beds of glaciofluvial material with overlying till (over the dotted line).

seems to have been transported a very short distance and has probably been accumulated very rapidly. The foreset bed consists mostly of horizontally or inclined bedded sand. Any eastern equivalent has not developed. The outwash-sediments there form a successive transition to both the distal and the proximal deposits.

During the third stagnation outwash-material has been accumulated in such large quantities that it has not only filled the whole Late-Glacial passage but has also been built up proximally above the then existing sea level. This outwash-plain, Ödskölds moar, can be divided into two submarine distal-plains at Björke and Ängenäs and one supermarine proximal-plain at Björsby. The dividing line is the Marine Limit which usually appears only as a limit between different material and disparate exterior or as a bottom-limit of glacial stream channels. Only to the East, a real (wave-cut?) slop is developed between the distal and the proximal parts.

The distal plains have even surfaces which not until the Kraxvad delta get a steep gradient and successively pass over to lower situated fine-sediments. They mostly consist of sand but some gravel and well-rounded stones are visible in rivulets and ditches. When deposited, both the plains have presumably formed a unit but are now separated from each other by a broad glacial stream channel

The Björsby plain lies proximally about 9 m. above the Marine Limit and slopes steeply towards the distal plains. The material is gravel and well-rounded stones but also small morainic boulders are found. The most remarkable featur is the occurrence of stony meltwater channels. They are 20—30 m. long, 1—3 m broad but usually only 1/2 m. deep. Near the Marine Limit, below which such channels do not occur, they are often coinciding, deeper and broader. Sometime

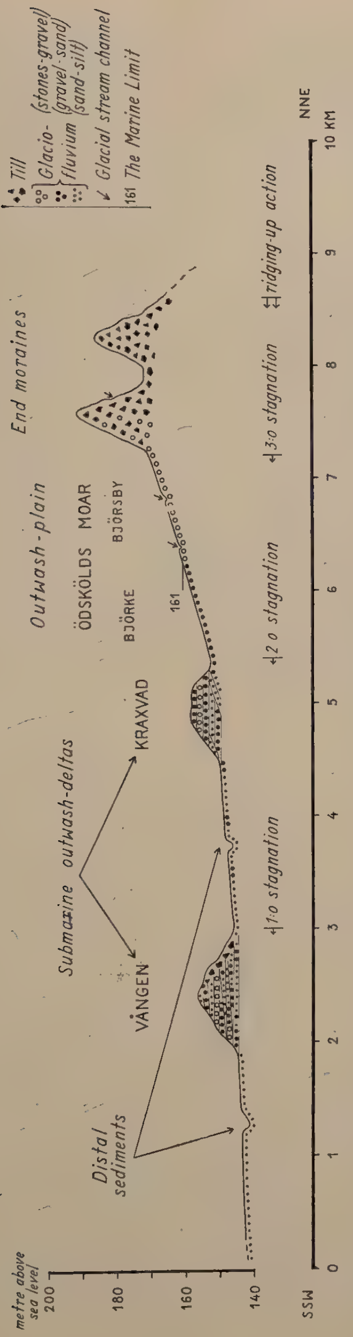


Fig. 8. Profile through the western part of the glacial complex at Ödsköld. The grain size distribution of the outwash-sediments is not analysed in detail. Only the dominating superficial composition is shown.

they end with a shallow and stony kettle. These are probably eroded by eddies where the cascading meltwater ceased on a plane surface or in stagnant water. The plain is also intersected by the deep channel which distally separates the Björke plain from the Ängenäs plain. While the short, shallow channels were certainly developed during the accumulation of the plain, this central channel is quite obvious of later origin, eroded since the plain was completed (cf below and page 363).

During the main stagnation, several small meltwater streams with a relatively invariable afflux have been used. As a consequence of that, the accumulation has been more constant and the material more homogeneous.

North of the Björsby plain two high end moraines have developed (fig. 8, 9). They are centrally broken by a deep gap which is the beginning of the stream channel, intersecting Ödskölds moar. This continues southwards to Vången, i.e. it is eroded also into the distal fine-sediments. It has accordingly been used during so long time, that a regression of the Sea of about 9 m. has occurred. The concluding phase of stagnation and ridging-up must have been very long.

Meltwater has also run at the short sides of the southern end moraine. To the East, the stream channel which proceeds down to the central channel, is open. To the West, the channel there has been obstructed by till, forming a low ridge (2 m. high) between the real end moraine and the valley side. This deposition must have occurred before the meltwater has ceased, for a new channel is eroded eastwards behind the ridge.

Owing to the central gap, both the end moraines are divided into a western and an eastern part. The western ridges have irregular sharp-edged crests (192 m. and 184 m. above sea level). The separating depression is primary and not eroded by meltwater. The distal sides of the walls are steep but relatively even and with only few superficial boulders. The proximal sides are uneven, pitted and richer in boulders. On the southern ridge, meltwater has eroded proximally and short, longitudinal boulder-notches or stream terraces have developed. On the northern ridge, the basis of the proximal side are resolved into hummocks and kettles. As it appears in some shallow sections, the end moraines consist of both coarse glaciofluvial material and till. The former predominates distally, the latter proximally. The ice margin has accordingly pushed up previously deposited stratified drift (proximal material of the Björsby plain) but till has been simultaneously supplied from the ice. So, the ridges are real push moraines. The irregular, low part of the proximal wall is, on the other hand, clearly of depositional origin, built up outside an ice margin in beginning break up. Probably this dumping accumulation has occurred just before the final recession from here i.e. when the wastage again began to predominate.

The eastern end moraines are broader but lower (187 m. and 177 m. above sea level). The most prominent feature here is the meltwater erosion on the proximal side of the southern ridge, in the separating depression and on the dista

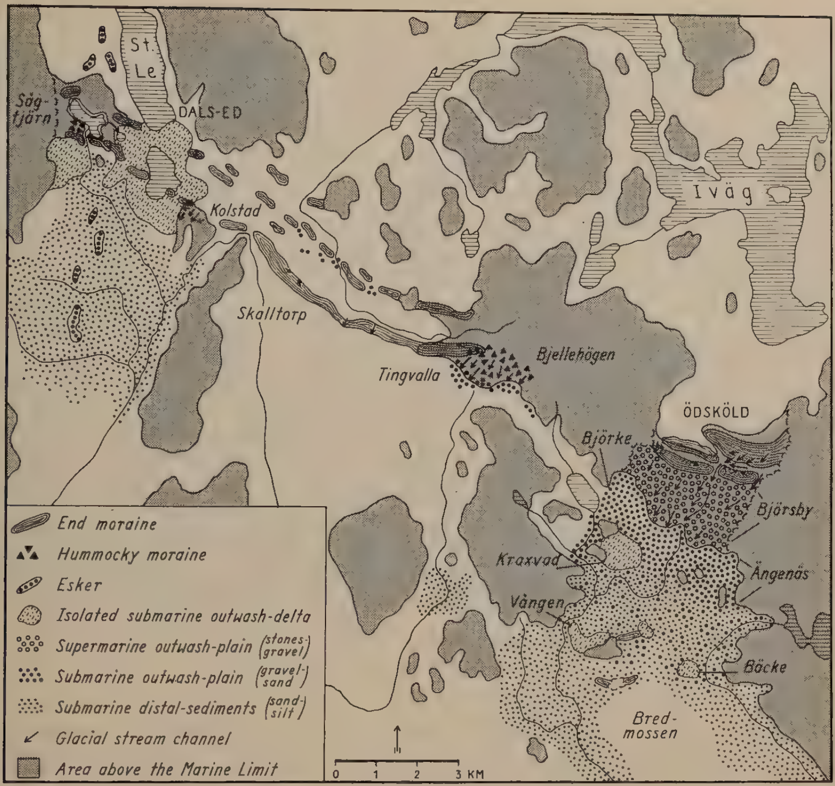


Fig. 9. The glacial complexes at Ödsköld, Skalltorp and Dals Ed. The height of the Marine Limit see fig. 1. The distal fine sediments are only marked in connection with the outwash-deltas but such material also occurs in large quantities in other places. The central stream channel through the outwash-plains at Ödsköld continues with the rivulet southwards to Vången.

ide of the northern wall. Several, short or long, transverse or longitudinal oulder-channels occur. They often end in a boulder-kettle, from which in some ases a new channel has developed. All the meltwater has finally gathered into main channel, sloping westwards and discharging into the central gap between he end moraines. The surfaces are here more even, especially on the northern idge, where the steep proximal side abruptly descends down to Lake Iväg. Conerning the material, the southern end moraine seems to consist, solely, of coarse ill, superficially very rich in boulders. Partly due to the lack of sections, partly ue to the clear re-arrangement of the boulder material by glacial streams, it is ifficult to determine the construction of this ridge. The large number of boulers and the somewhat irregular shape point to a depositional origin but thrust ovements must not be entirely precluded. In the northern wall, till predominates distally. Glaciofluvial material is, on the other hand, common proximally, sometimes even dominating. Presumably it was accumulated in connection with the extensive meltwater erosion between the end moraines. This ridge may more definitely be characterized as a depositional end moraine.

The Ödsköld complex is one of the best developed marginal glacial deposits in Sweden. Such a concentration of so different terminal elements is hardly found in any other place. Usually, large outwash-deltas or end moraines occur separately, and supermarine outwash-plains are very rare. Furthermore, the glacial stream erosion has seldom had such a dominating effect. The Ödsköld complex can therefore be compared to similar forms in Germany (Woldstedt 1923), Denmark (Milthers 1948), Iceland (Woldstedt 1939) and Alaska (Tarr 1908) but there the supermarine plains are lacking.

From Ödsköld a narrow Late-Glacial passage led over to more open terrain at Tingvalla. Several small gravel-plains occur there, near the Marine Limit. The material is badly sorted and has been clearly transported a short distance. These accumulations are small deltas at the mouths of short meltwater streams on the northern valley slope.

On the steep side of the height Bjellehögen, there appears ablation moraine in form of sharp-edged boulder-knolls and shallow boulder-kettles (up to about 192 m. above sea level). A few glacial stream channels are visible towards the Marine Limit. Above this locality some badly developed shore terraces can be observed. Temporary meltwater ponds have apparently existed between the distal, remaining dead ice, the tops of the height and the proximal ice margin.

At Tingvalla the valley side is more flat and the ablation moraine there has another character. On the upper parts, irregular knolls and ridges still predominate. However, they are more isolated here, are less rich in boulders and are not so sharp-edged. They are, furthermore, separated from each other by relatively even ground, in which some deep (2—3 m.) kettles occur. These are either conical and circular or more longish. The former are usually isolated, the latter often discharge into a small channel, sometimes leading over to a new kettle.

The outer part of this locality is somewhat steeper. Only a few hummocks of ablation moraine are developed but instead several channels exist (1/2 m. deep, 2—5 m. broad). These are usually short and end on more even ground or in boulder-kettles. Towards the basis of the valley slope a few longer and deeper channels are eroded (fig. 10). Some of them reach the Marine Limit, where often small gravel-deltas occur. Probably they can be regarded as main channels which have been used during a longer time than the other, more intermittent channels.

Immediately to the West, i.e. where low terrain begins, the ablation moraine again changes its character. The hummocks now form a transverse ridge. After only about 50 m. they join together a real end moraine which then continues

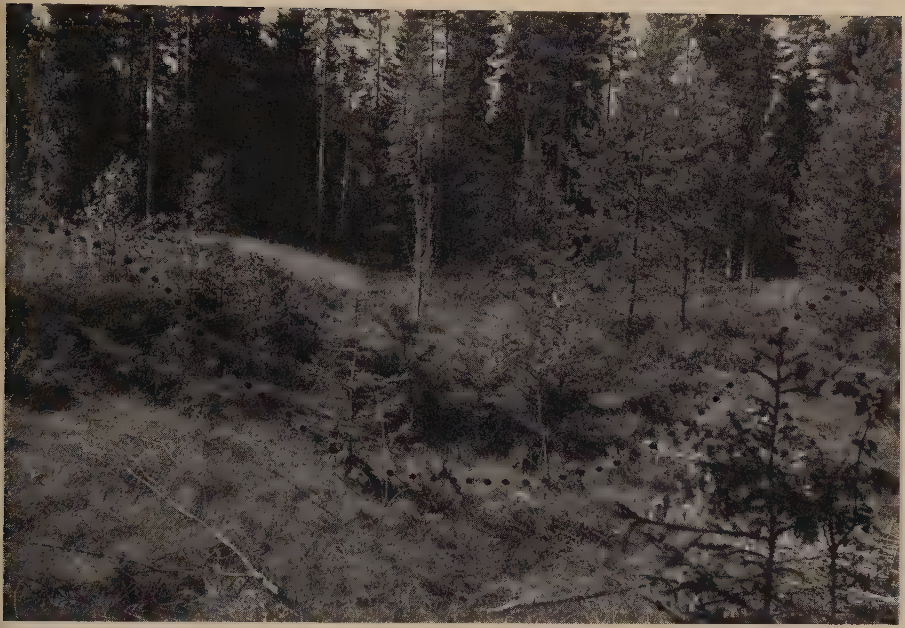


Fig. 10. Glacial stream channel, distally of the hummocky moraine NE. of Tingvalla.

westwards for about 6 km. This Skalltorp ridge has a more varying appearance and composition than any other end moraine in Dalsland. While the height is elatively constant (5—8 m.), the breadth varies between 50 m. and 160 m. To he East, the wall is connected with the hummocky moraine at Tingvalla, to the Vest a steep short side is developed.

The eastern part which lies above the Marine Limit, is a simple ridge with a harp-edged but irregular crest. Both the distal and the proximal sides are steep out the latter is in some cases pitted and influenced by meltwater. The material s only till, essentially of a similar composition as in the adjoining ablation moraine. This part of the end moraine must therefore be characterized as a dump noraine, forming a transition between the hummocky moraine to the East and he real, submarine end moraine to the West.

The middle part of the Skalltorp ridge has a steep proximal and a more sloping listal side. The latter is sometimes secondarily deformed and redeposited gravel ccurs on the low part of it or quite outside the wall. The crest, proximally displaced, is irregular and here and there broken by shallow and stony gaps, eroded y meltwater streams (cf De Geer 1909). On that account, isolated tops, resembling small knolls, have developed (fig. 11). As several sections show, this wall onsists of both till as well as varying stratified drift. To the East, the former is ooser, more variably orientated and rich in boulders; to the West, where it be-ame dominating, it is more dense and compact and the boulders have a more

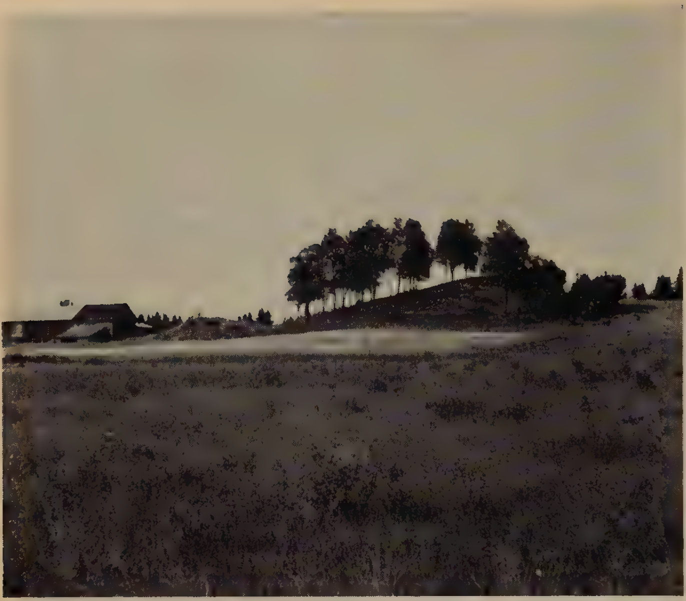


Fig. 11. Isolated crests on the Skalltorp end moraine. The gap between them is eroded by meltwater.

preferred orientation (parallel to the ice movement). The glaciofluvial material which is always of secondary importance, is most common in the central part but is often covered by till proximally and to the top. In latter case small deformations of the stratification can be observed. Also in the till a similar disturbance of small layers of sand is visible. These derangements must indicate a pressing, active ice margin, possible real ridging-up movements. The composite construction may also point to a development during two subphases.

The western part of the Skalltorp end moraine is divided into an outer and an inner ridge, both with distal crests. The former is broader and higher, the latter is lower and proximally more irregular and with marks of glacial stream erosion. Also small boulder-kettles occur, probably indicating remaining ice blocks. The material seems to be entirely till. In the distal ridge it is more dense and compact and with boulder orientation mainly perpendicular to the ridge. On the distal slope, however, a great percentage of the boulders has an orientation parallell to the ridge (fig. 6), possibly indicating an initial ridging-up by pushing actions. In the proximal ridge the till has distally a similar character but proximally gets a looser composition and became richer in boulders. Two subphases of development have apparently occurred (cf the middle part). The first was the more active one; then the ice movements have successively decreased, resulting in a concluding deposition of debris mostly by dumping. Simultaneously, subglacial meltwater has appeared, partly accompanied by an increased calving.

Proximally of the Skalltorp end moraine there is a series of small ridges. Only he eastern one is a sharp-edged wall with steep sides and an irregular crest above he Marine Limit. The other ridges are low and consist of looser till as well as insorted stratified drift. They are presumably typical depositional end moraines. n some cases glaciofluvial gravel occurs in the gaps between the ridges, probably howing discharges of subglacial streams. During this third stagnation, the pre-ious continuous ice margin seems to have dissolved into different ice lobes etween more or less ice free heights.

Westwards the complex at Dals Ed follows directly (fig. 9). As that has been nalysed by De Geer (1909), there is no point in describing it again in detail. Only some complementary additions will be given.

According to De Geer, a high end moraine is developed at Kolstad. Only the vestern protruding part, however, is a real end moraine, the rest can only be haracterized as a till-concentration on a proximal valley slope. If it is entirely f terminal origin, it is consequently difficult to determine. But as ablation mo-aine occurs in the form of small hummocks, some material might have been leposited from the adjoining ice terminus. The most interesting problem is, how-ver, the extensive glacial stream erosion.

Near the pass-summit southwards, several boulder-channels are developed. ocally, also the bedrock has been eroded and some embryonic potholes are isible. The channels are very varying as to breadth, length and direction. Often everal ones end in a boulder-kettle, from which sometimes a new channel fol-ows. Most of the meltwater has drained off southwards over the high precipice bove Lake Tössbotjärn. The latter, which at that time was submarine, is cer-ainly a deep pothole. Some channels discharge into a steep main channel, eroded ownwards to the outwash-delta to the West. The channels towards the pass-ummit are most deeply eroded proximally, i.e. backwards in the direction of urrent. Probably that was due to the cascading meltwater having to stream up he valley slope under high pressure.

The other part of the Dals Ed complex which will be discussed, lies western-ost. S. of Lake Sågtjärn a small outwash-delta has developed near the Marine imit. It is separated from the Dals Ed delta by distal fine sediments. The un-ulating accumulation-plane is preserved and low current-ridges are still visible. roximally from here, a few supermarine ridges and knolls occur. The southern nes are sharp-edged, transverse walls, consisting of both glaciofluvial material nd till. They may be characterized as kame moraines. The northern hummocks re irregular and entirely composed of till rich in boulders. Between them shallow oulder-kettles occur. This hummocky moraine apparently indicates a collapsing e margin and then remaining dead ice. Owing to this development, meltwater as ponded behind this dead ice and a small proglacial ice-lake appeared in the alley of Lake Sågtjärn (165—166 m. above sea level). The outlet went east-ards down to Lake Timmertjärn which perhaps may be regarded as a deep pothole. A narrow channel, partly following a fissure zone in the bedrock, is eroded. In all probability, it is extralateral and not subglacial as De Geer (1909) has supposed.

As the terminal forms are constructed and situated at Dals Ed, this locality apparently began its development as a deep calving-bay with discharging subglacial streams. The earliest accumulations were outwash-material in the form of esker hills (fig. 1). When the main stagnation then occurred at the mouth of the deep valley-basin of Lake St. Le, the filling of the whole valley with outwash-sediments began. As often is the case, the identation of the calving-bay is shown by the direction of the adjoining end moraines. To the East, the Skalltorp ridges have an oblique NW. course towards Dals Ed. To the West, similar end moraines are lacking, however, owing to the occurrence of a high, probably soon ice free, valley side.

According to De Geer (1910), the drift border continues with several end moraines on the plateau NW. of Dals Ed. During the investigations of the present author, none of these ridges could be identified. The high plateau is characterized by relatively even ground with peat-bogs and small heights with ground moraine of different thickness. Hummocky moraine which often occurs in such terrain, is nearly lacking.

The drift border continues instead towards SW.-W. but these western elements are very inconsiderable and are very sporadical. At Hökesäter an accumulation-plain of fine glaciofluvial material is developed. Some coarse material occurs N. from here and sometimes near the Marine Limit. However, these sediments cannot be regarded as a real outwash-delta but they are certainly accumulated outside a small ice lobe. At Mon there is a broad, comparatively even end moraine which mainly consists of coarse stratified drift. Certainly, it was originally built up as a supermarine outwash-plain but later on, dense and compact till was disposed proximally and partly upon the glaciofluvial material. Distally, a few, short stream channels have been eroded, some of which reach the Marine Limit. At Skottan some irregular ridges of till rich in boulders and unsorted stratified drift occur, and near the Norwegian border a few »rock moraines» are found (at Norane and Högen). The morainic belt then continues in Norway in the valley Enningdalen.

The main border W. of Kroppefjäll is accordingly very composite as to both construction and composition. More than the other drift borders in Dalsland it is, as to its position, topographically controlled. During the first stagnation, two large ice lobes seem to have been developed in the valleys at Ödsköld and Dals Ed. Extensive subglacial streams were concentrated there and so glaciofluvial accumulations are dominating deposits. In these valleys the ice margin has also shown more definite activity, and real ridging-up has occurred. Usually the construction of end moraines has appeared as a concluding process of a stagnation subphase.

In the somewhat higher but more even terrain between those valleys, the ice terminus was originally relatively straight. During the first stagnation it was really active but then became more and more stationary and finally began to dissolve into separate lobes. Glaciofluvial material is of secondary importance.

To the West, the large plateau between Lake St. Le and the Kornsjö valley seems to have been nearly ice free distally. Only in some narrow valleys, overhanging ice lobes have reached farther southwards and only outside them small terminal forms could develop.

The end moraine construction

According to conventional views, end moraines are built up either by thrusting actions or by depositional processes (Chamberlin 1894, Flint 1941, 1947). The former type, the thrust (push) moraine, ought usually to have a pronounced steep, proximal side, formed by the pressing ice margin. The till has a variable composition but it is often compact owing to the pushing process. Sometimes therefore, it resembles basal till which, indeed, may occur in greater quantities than in a dump moraine. Due to the ridging-up of previously deposited debris, other material than till, as stratified drift and fine sediments, will be embodied into the ridge. If a stratification is still visible, thrust features of different kinds are common. The superficial distribution of boulders is variable and a comparatively great percentage of them may lie parallel to the long-axis of the wall (cf Lundqvist 1949).

Here in Dalsland, indubitable thrust moraines are only found at Ödsköld, where the composition and the form of the western ridges indicate such a development. As regards the deformations of the stratification but also the form, the middle part of the Skalltorp ridge may be a real thrust moraine, too. During the formation of the wall at Hjortens udde, pushing processes may also have occurred.

As end moraines of very different form and composition are so common here, this slight representation of thrust moraines is a remarkable fact. But such end moraines, built up during stagnations of the deglaciation period, are probably rare. An important circumstance for an explanation of that seems to be the proportion between the duration of a stagnation, the necessary conditions for a continuous thrust action and the extent of formed end moraines.

A ridging-up by thrust movements presupposes an advance of the ice margin. But this process could hardly have continued long enough for a large end moraine to be formed. The created ridge must soon have been too large an obstacle for the oscillating ice and so comparatively rapidly has dimished and probably even prevented a continuous pushing action. The ice margin might instead have been stationary and the following enlargement of the wall have occurred by depositional processes (cf below). If, on the other hand, several oscillations appeared during a stagnation — and that does not seem to be improbable as regards the usual dividing of such a time into several subphases — it will be remarkable, if each advance of the ice margin had reached the first position. It is more probable that several small thrust moraines had been formed in succession.

So thrust moraines, built up in similar terrain and under similar conditions as here, are presumably formed all at once and are of small extent or only constitute a part of a large ridge of essentially depositional origin.[1]

These objections to a construction by thrust actions seem to be entirely inconsistent with the occurrence of the high thrust moraines at Ödsköld. But this is only an apparent incompatibility, for these ridges must be regarded as exceptions to the rule, certainly due to the topography there. The accumulating ice lobe was situated in a deep valley-basin and its margin moved against a narrow passage, probably with a high threshold. As the surrounding plateaus indubitably were ice-free, the ice terminus could not have been so high that it was capable of forcing over the pass-summit and into the passage. Instead, it came to lie continuously pressing against the valley precipice. As this process continued for a long time, the result was a ridging-up of drift at the very threshold between the passage and the valley-basin, and so high thrust moraines were formed there.

Most of the end moraines in Dalsland must accordingly be of depositional origin. According to investigations in other areas, dump moraines are the most common type, the characteristic features of which seem to be the following ones (Chamberlin 1894, Flint 1941, 1947). The material (essentially till) which is detached from the ice margin, is irregular distribuated, of looser composition and comparatively rich in stones and boulders, and so resembles (and perhaps is) superglacial till. Most of the boulders use to lie distally. As regards their orientation, it ought to be more variable but it is mostly perpendicular to the ridges. That must indicate that the movement of the ice and its material proceeded right up to the moment, when the deposition took place (Lundqvist 1949). A dump moraine has scarcely any distinct form but the distal side may originally be more sloping than the proximal one and the surface is often irregular with small hummocks and kettles.

Can all the depositional end moraines here now be characterized as dump moraines? The answer is no. But the following ridges are unmistakable dump moraines, namely the Näsöl end moraines, the eastern part of the Skalltorp ridge and the kame moraines at Lake Sågtjärn. The small ridges of the southern drift border W. of Kroppefjäll and the inner series of end moraines at Skalltorp are possible of similar kind.

Furthermore, some large ridges formed in another manner have irregular roximal slopes, indicating a dumping deposition, often accompanied by appear-nce of meltwater. The cause of such a concluding modification in the terminal ccumulation has in some localities been the occurrence of projecting rocks at he ice margin (at Mellerud) or emerging of deglaciated heights right behind it at Skalltorp). On that account, the ice terminus has begun to break up — resumably by an increased calving — resulting in a dumping process. A similar evelopment might also have occurred as a first manifestation of a recession in eginning, i.e. when the wastage again came to predominate over the downward owing of ice to the margin (at Ödsköld) (cf Hoppe 1948). In many cases, also he end moraines themselves were probably the cause of such a concluding ac-umulation. When a ridge, i.e. the obstacle, had got larger dimensions, it dimin-hed the rate of flow of the terminal ice and so caused a greater ablation and n that account a transition to a deposition by dumping (cf Flint 1947).

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[1] Thrust moraines, even extensive ones, seem to be the most common type of end moraines in many areas as, for instance, in the areas of maximum extent of the last ice sheet or in steep terrain with rapidly flowing valley glaciers (Todtmann 1932, Schott 1933, Milthers, K, 1935, Gripp 1938, Woldstedt 1938, Milthers, V. 1948). However, the conditions for flow, regimen, position etc. of the ice were(or are) there completely different from those in Dalsland or similar deglaciation areas.

Also real dump moraines are accordingly few in Dlsland. The remaining ter-inal ridges have usually a form and a composition, clearly inconsistent with this pe.

The till which is always the formative material — even if stratified drift occurs istally or towards the bottom — is usually dense and compact and rich in oulders only up towards the surface (fig. 3, 5). In nearly all the sections, foli-tion or a similar flaky and with the surface parallel structure as well as small yers of sand are visible (fig. 3, 5). This composition and these structures are haracteristic of basal till, deposited under high pressure of overriding ice (Lund-vist 1940, Flint 1947, Gillberg 1955). The boulders predominate on the proximal opes, they are often pressed into the matrix and they have a preferred orien-tion perpendicular to the long-axis of the ridges (fig. 2, 3, 5), i.e. indicating deposition in movement. As regards the form of these end moraines, it is usually symmetric with distal crests, steep distal sides[1] and gradually sloping, sometimes ery long, proximal sides (fig. 2). The ridges resemble therefore sand dunes.

All these facts indubitably indicate a subglacial, gradual accretion of debris by continuous flowing and pressing ice, i.e. a lodging process (Chamberlin 1894, lint 1941, 1947). End morains built up in this manner must therefore be char-cterized as lodge moraines. But how could such a construction of terminal ridges ally occur?

As is evident from the descriptions of the drift borders, several of the lodge oraines seem to have begun their development in another manner. The first sult of a stagnation has sometimes been the forming of a low ridge of till by rust actions (at Mellerud and Skalltorp)[2]. In some places, glaciofluvial ac-mulations (at Bräckan and Hajum) or rocks (the »rock moraines») have

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[1] As winds from S.-SW. have predominated during Late- and Post-Glacial time and as a clear de-uction of some end moraines has been observed (cf page 337, 340), a sharpening of the distal pes may have occurred in some places.

[2] This primary wall could certainly have arisen by dumping, too, although that has not been proved ywhere.

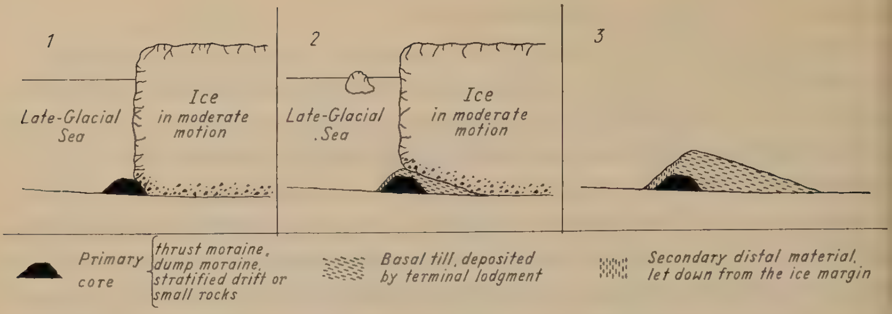
1
Late-Glacial Sea
Ice in moderate motion
2
Late-Glacial Sea
Ice in moderate motion
3
Primary core
thrust moraine, dump moraine, stratified drift or small rocks
Basal till, deposited by terminal lodgment
Secondary distal material, let down from the ice margin

Fig. 12. The probable construction of a lodge moraine.

1) The initial phase: A primary core outside the ice margin.
2) One phase of the construction: A gradual addition of basal till upon the primary core; some debris slumping and sliding down on the distal slope; calving at the ice margin.
3) The complete lodge moraine.

formed such a primary core. The cases where the ice has deposited a mantle of till on the stratified drift without dislocating the latter and mixing it into the till mantle (cf fig. 7), seem to be really conclusive proofs of a subglacial, lodging deposition. A thrust action would imply such a mixed deposit. Also as regards the “rock morains”, only such a basal addition of debris as proximal mantles may be compatible with their form.

In all probability, a primary core was a necessary conditions for a terminal lodgment, perhaps even was the real cause of it. Anyhow, this obstacle then served as the foundation and as the outer limit for the overlying and lodging ice (fig. 12). A proceeding enlargement to a lodge moraine could scarcely have occurred without a continuous and impeded transfer of ice and debris towards the ice margin. The topographical conditions there and in the back-ground must therefore have been of vital importance. However, this ice movement may have been comparatively moderate. A very rapid or increasing rate of flow would have caused, instead, either a thrust action and so a forming of thrust moraines or more probably, a complete overriding of the previously deposited material and so a transforming of it to drumlinoidal hills or real drumlins.

Also another process seems to have assisted at and promoted this development As the ice terminus ended in deep water, it may have been floating when reaching the distal crest of the lodge moraine in forming. A carrying away of superfluous ice (and debris) by calving must therefore have occurred, perhaps even have been necessary for counteracting and balancing the downward transfer of ice. But some debris has certainly also slid and rolled down on the distal side If such material now covers the primary wall in large quantities, it may occasion an incorrect interpretation of the method of deposition, of the boulder orientation and so of the whole construction of the end moraine.

A terminal lodgment apparently depends on several necessary conditions. It i ıus comprehensible that lodge moraines seem to be the most uncommon type f end moraines (cf Flint 1941, 1947). But as evident from the discussions and escriptions above, such a formation might really have occurred in Dalsland. everal of the largest ridges are lodge moraines, namely the western part of the ärn end moraine, the Bräckan wall, the eastern part of the Mellerud end moaine, the Hajum ridge, the Råggärd end moraine and the western part of the kalltorp end moraine. Moreover, the ridges at Brålanda and Tåsterud, the iddle part of the Mellerud end moraine, the Röse wall and the ridges W. of åggärd have probably partly been formed by lodging processes.

The Marine Limit

The Marine Limit of the area is mainly described in a previous paper (Gillerg 1952). Some complementary notes may be added, however.

The Marine Limit has usually been determined as the uppermost wave-washg level. At Vången, Kraxvad, Tingvalla and Dals Ed, for instance, it is also efined as the upper limit of outwash-deltas, at Ödsköld as a limit between difrent outwash-material and in some places (at Ödsköld, Tingvalla and Dals Ed) the bottom-limit of meltwater channels[1].

It is often considered that the Marine Limit only gives informations of the ighest stage of the Late-Glacial Sea. Careful and numerous determinations can so prove several details of the land elevation and the deglaciation. However, ere is no reason to discuss the former problem here. It may only be pointed out at all the new values of the height of the Marine Limit clearly confirm the evious shown steep gradient (Gillberg 1952).

Concerning the deglaciation, the height of the Marine Limit here reveals an portant fact. N. of the main borders, this shore line always lies about 7—9 m. wer than at the drift borders themselves. Before the recession from there took ace, a land elevation of about 9 m. thus occurred. That exactly corresponds to e fact, that the central stream channel at Ödsköld, which cannot have been ed after the beginning of the recession northwards, has its mouth about 9 m. low the Marine Limit. The main stagnation must have been a very prolonged ase of development.

As the outwash-delta at Kärr and contemporaneous "rock moraines" lie where e Marine Limit has its lowest height above sea level, they have obviously been rmed only after the regression of the Sea from its highest level at the main rder. The difference in time between these stages of the Late-Glacial Sea was obably so great that these terminal elements may be considerably younger than the northern drift belt (cf page 344) and they may indicate a new stagnatio phase, entirely independent of the main stagnation. However, as terminal form occur only sporadically, this concluding stagnation-phase might have lasted a comparatively short time and have been of less extent. But in spite of its unequivocal independence, this stagnation of the ice margin must be interpreted as the last cold fluctuation during the whole Middle-Swedish stagnation phase before the rapid ice recession during Pre-Boreal time.

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[1] De Geer (1909) has located the Marine Limit at Dals Ed to about 169 m. above sea level. As ave previously shown, it only reaches a height of 160 — 161 m. above sea level (Gillberg 52). Above all, it is defined as a bottom-limit of glacial stream channels, which fact also De er has observed in many localities. His two values of 169 m. probably refer to places with redesited material, formed in small, local meltwater ponds behind some end moraines.

General conclusions

While the ultimate cause of the Middle-Swedish stagnation period was certainly climatic fluctuations (the climatic deterioration during Younger Dryas time), the extension as well as the disparate composition and the different position o the drift borders in separate areas my be ascribed to topographical conditions here and to the North.

E. of Kroppefjäll there is a relatively even and low plain with a deep and large easterly depression and a large, comparatively low back-ground. W. of Kroppefjäll there is a dissected terrain with narrow and often deep valleys and a back-ground of similar character or still more variable. With such a variation of the topography it is comprehensible that the ice in different areas has reacted in a different manner as regards the movements, the forming of terminal elements, the position of the front and so on.

The area E. of Kroppefjäll and to the North must have been covered by a large ice of a relatively uniform thickness and with an essentially straight terminus. A continuous downward transfer of ice and debris to the margin could therefore occur. On that account, small changes in the configuration of the subglacial floor have only been a local factor in determining the appearance and position of the ice front. Also small changes in climate, the subphases of a great stagnation, for instance, might have been of similar secondary importance. The forming of small end moraines in series will therefore have occurred more seldom. This probable stability of the ice margin against small variations in climate and topography seems to explain the surprising fact that only one morainic belt ha developed during each stagnation phase.

Owing to such an impeded continuity of ice movement, it is comprehensibl that till is almost the only terminal material on the Dalbo plain. Small glaciofluvial accumulations could appear only as the result of local conditions. But it i just as clear that end moraines are the dominating terminal elements and tha most of them seem to be formed by lodgment. This active flowing towards th ice terminus has certainly been most considerable in the depression of Lak Venern. On that account, the ice moved farther southwards in this area and go a SE.-NW. margin to the flanks. The only notable fact is perhaps that it did no come into a still more southern position there. Presumably that indicates a rel tively low ice front which has been floating and calving. Owing to this differnce in the ice movement on the Dalbo plain and in the depression of Lake enern, the ice activity has been very changing in the transition zone between hese areas. The construction of terminal elements there has consequently been ery complicated.

Calving has indubitably played an essential role in the depression of Lake enern, along the slopes and in the low terrain E of Kroppefjäll, partly as countracting the continuous ice activity during the stagnations, partly as the main ethod of recession during the intervals between the stagnations (cf Hoppe 948).

In the area W. of Kroppefjäll and to the North, the ice must have had a ariable thickness and near the margin has been more or less divided into separate bes between partly deglaciated plateaus. Owing to the latter fact, the wastage ust have had a great effect, occurring in small areas and being helped by warmd air from reflecting plateau sides. As the valleys are often deep and have preumably a changing bottom-configuration, the calving might have been of deciive importance. Occurring humps and narrowed sections may locally have enorced topographical stagnations of short duration (cf Gillberg 1956). But also mall changes in climate — during different subphases, for instance — have ertainly had a similar effect, resulting in the forming of separate terminal elenents or a multiple composition of a large glacial complex.

Owing to all these circumstances, the separate ice lobes have occupied different ositions. Furthermore, the recession has been more changing but on the whole omewhat more rapid than on the Dalbo plain.

As, in such a broken terrain, the ice motion has essentially been concentrated the valleys, occurring terminal ridges are typical valley end moraines (cf Ioppe 1948). Owing to reflecting heat and current of warmed air from the urrounding, partly deglaciated plateaus, great quantities of meltwater have ppeared, gathering into the valleys. As a rapidly melting ice produces more tratified drift than till, glaciofluvial accumulations are the dominating terminal orms. Sometimes end moraines were developed in proximal connection with utwash-material. In all probability that indicates a short-timed intensification f the severe climate, resulting in a complete ceasing of meltwater and instead n entirely determining effect of the ice movements.

According to previous views in Sweden, both the drift borders in Dalsland beng to the Middle-Swedish morainic system, i.e. were formed during Younger ryas time. Nilsson (1953, 1960), however, combines the southern moraines here nd in Vestergotland with a Middle-Gothi-Glacial morainic belt in the Vettern epression. In lack of definite datings both drift borders in Dalsland have been ssigned to Younger Dryas time in this paper. The course and development of ne Marine Limit here and in similar stagnation areas seem further to confirm that both these moraines belong to one and the same deglaciation substage (Gillberg 1952).

The period of colder climate which appeared during Younger Dryas time may scarcely have reached its culmination immediately. Other periods of similar character have usually been divided into several phases and have attained its maximum somewhere during the middle part or towards the end of their development (Caldenius 1942, Björsjö 1948, Gillberg 1952, 1956). The intervals of more intensified severe climate were characterized by stagnations of the ice margin and the forming of terminal stagnation elements. The time between different stagnation phases corresponds to recession of the ice margin. A dividing of a substage into several drift borders seems therefore to be a characteristic feature.

As regards the Middle-Swedish substage, such a periodicity clearly occurs in Finland and seems to be nearly realized in Östergötland, Västergötland and Norway. The most probable may therefore be a similar dividing of this substage in Dalsland, and in all probability such is the case. In such an event, the southern drift borders may represent an initial stagnation-phase, the main borders a culmination stagnation-phase and the Kärr delta etc. a concluding stagnation-phase.

The character of the middle drift border W. of Kroppefjäll is more debatable. Two interpretations may be possible, this moraine being built up either during a stagnation phase of similar amplitude as the initial one or only during an early subphase of the main stagnation. What speaks in favour of the first alternative is the decided large extent and the comparatively large distance to the next morainic belt. It seems therefore, in regard to the conditions here, most correct to assign the middle drift border to a clearly independent, second stagnation-phase which indubitably, however, indicates the beginning of the intensified colder climate during the culmination phase.

A more remarkable fact is perhaps that terminal forms of the concluding stagnation-phase seem to be lacking N. of Ödsköld and Dals Ed. The most plausible explanation is naturally that the proximal end moraines there have been formed during this concluding stagnation. But several facts show that this is an impossible hypothesis. N. of Dals Ed, the height of the Marine Limit decreases successively northwards and reaches its lowest stage not until several km. to the North. As it has been proved above (page 363), the concluding phase occurred during or somewhat after the lowest stage of the then existing Sea. At Ödsköld the appearance of the central stream channel may indicate a similar difference in time. The proximal end moraines at Ödsköld and Dals Ed must accordingly have been formed in direct connection with the proximal deltas, not only as to the position but also in time[1]. The lack of concluding terminal elements here may be due to other causes. Possibly the topography has played an important role.

[1] As the Marine Limit reaches its lowest height directly N. of the proximal end moraines at Ödsköld, it may be possible that the ice margin was stationary at these ridges also during the concluding phase. In such a case, the forming of the irregular, proximal slope of the western end moraine may correspond to this stagnation.

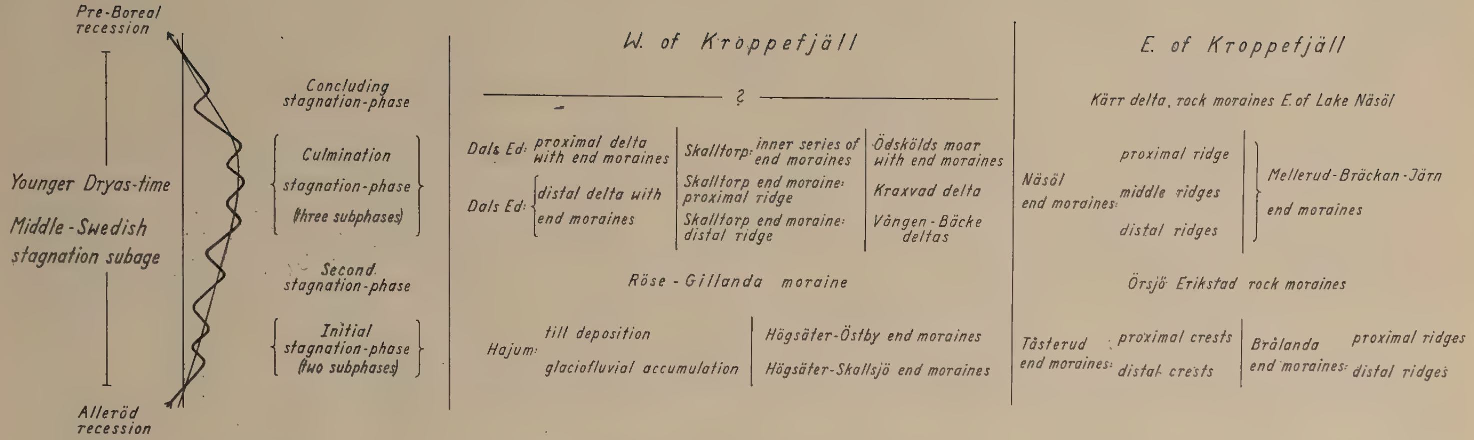
Pre-Boreal recession
Younger Dryas-time
Middle-Swedish stagnation subage
Alleröd recession
Concluding stagnation-phase
Culmination stagnation-phase (three subphases)
Second stagnation-phase
Initial stagnation-phase (two subphases)
W. of Kroppefjäll
E. of Kroppefjäll
?
Kärr delta, rock moraines E. of Lake Näsöl
Dals Ed: proximal delta with end moraines
Dals Ed: distal delta with end moraines
Skalltorp: inner series of end moraines
Skalltorp end moraine: proximal ridge
Skalltorp end moraine: distal ridge
Ödskölds moar with end moraines
Kraxvad delta
Vången-Bäcke deltas
Näsöl end moraines: proximal ridge
middle ridges
distal ridges
Mellerud-Bräckan-Järn end moraines
Röse - Gillanda moraine
Örsjö Erikstad rock moraines
Hajum: till deposition
glaciofluvial accumulation
Högsäter-Östby end moraines
Högsäter-Skallsjö end moraines
Tåsterud end moraines: proximal crests
distal crests
Brålanda end moraines: proximal ridges
distal ridges

Fig. 13. The development of the Middle-Swedish stagnation subage (Younger Dryas time) in Dalsland.

N. of these localities, deep valley-basins with narrow strips of land between them and the surrounding plateaus occur. On that account, the forming of terminal elements might have been obstructed. Furthermore, the calving has certainly been of such a great importance that the short-timed concluding phase could not assert here.

A stagnation phase in its turn has often been divided into two or several subphases which represent the actual times of the terminal drift formation. As regards the southern drift belts, there are only slight indications of such subphases. The Tåsterud ridges have two longitudinal crests which in the description above were associated with a double ice activity. As in all probability this development was due to climatic fluctuations, the initial stagnation-phase has included at least two subphases. Also the multiple construction of the drift belt at Brålanda and W. of Kroppefjäll seems to prove the same, possible also the composition of the Hajum ridge.

The main border on the Dalbo plain is obviously very uniform and seems to indicate a continuous development rather than different subphases. Only the composition of the Bräckan wall and some parts of the Mellerud end moraine may suggest two subphases; the Näsöl ridges certainly indicate three ones. W. of Kroppefjäll, the main border is clearly composite. The Ödsköld complex and the Skalltorp end moraines indicate three subphases. As regards the Dals Ed complex, the interpretation of it is more discussable. If the distal delta and the distal end moraines are regarded as one unit, like the proximal delta and end moraines, only two subphases can be established. But these distal elements may also represent two different stages of development and, in such a case, the Dals Ed complex also indicate three subphases.

As is evident from the construction of the terminal elements, the course of development has been very divergent in different localities and during different stagnation phases. Sometimes, a short but probably rapid recession without any terminal deposition whatever has occurred between two subphases. In that case, the different terminal forms lie apart (the Brålanda ridges, the southern moraines W. of Kroppefjäll, the Näsöl ridges). Sometimes, the interval between two subphases has been characterized by a slow recession, accompanied by a slow but continuous terminal accumulation and, in such a case, the end moraines and divided into a distal and a proximal ridge (the Tåsterud end moraines, the western part of the Skalltorp ridge). Alternatively, the time between two subphases sometimes only represented a pause in the terminal formation and, in such a case, the different terminal elements form a unit (the Järn-Bräckan-Mellerud end moraines) or large glacial complexes have developed (at Ödsköld and Dals Ed).

Summary

On the basis of the construction of the morainic belts in Dalsland, the development during the Middle-Swedish subage (Younger Dryas time) might have occurred as follows (fig. 13):

1) An initial stagnation-phase, — probably including two subphases, approximately equivalent in amplitude,
2) a recession,
3) a second stagnation-phase, — locally of great extent,
4) a recession, — shorter than the former,
5) a culmination stagnation-phase, — probably of long duration and including at least hree subphases of comparatively equivalent amplitude; large glacial complexes were built up,
6) a recession, — very short on the Dalbo plain; W. of Kroppefjäll either the beginning of the final recession northwards or no recession at all,
7) a concluding stagnation-phase, — presumably of short duration and only on the Dalbo plain obviously leaving behind local stagnation forms.

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The Ca/Mg ratio in the limestone deposit at Stora Vika

By

ERIK HÖGBERG

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ABSTRACT

The limestone deposit at Stora Vika, to the south of Stockholm, has been studied with special reference to the distribution of magnesium in the limestone. Such a study has also purely practical aspects, since the MgO-content of Portland cement may not exceed 5 % according to Swedish cement standards.

The investigation of the occurrence of pre-Cambrian carbonate rocks, which are considered to belong to the oldest sequences of rocks in Sweden, has shown that both limestone and dolomite stone occur within the same deposit. There are no successive transitional forms between the two rocks. The Ca/Mg ratio is 2 in the dolomite stone, and averages 20 — never below 10 — in the limestone. Calcite occurs commonly and in rather large quantities in the dolomite stone and is, in the present author's opinion, a reaction product formed in metamorphic processes between dolomite and silicic acid. In limestone, on the other hand, only isolated dolomite crystals occur. The highest magnesium content in the limestone is found in restricted areas, in which occur spots of a green forsterite mineral. Dolomite is also present in large quantities in the limestone in these zones. Diopside and phlogopite are the most common minerals in the limestone, and forsterite and phlogopite in the dolomite stone.

In comparison with other deposits of carbonate rocks in the leptite-hälleflint series of Central Sweden, the author has observed many similarities as regards tectonics, degree

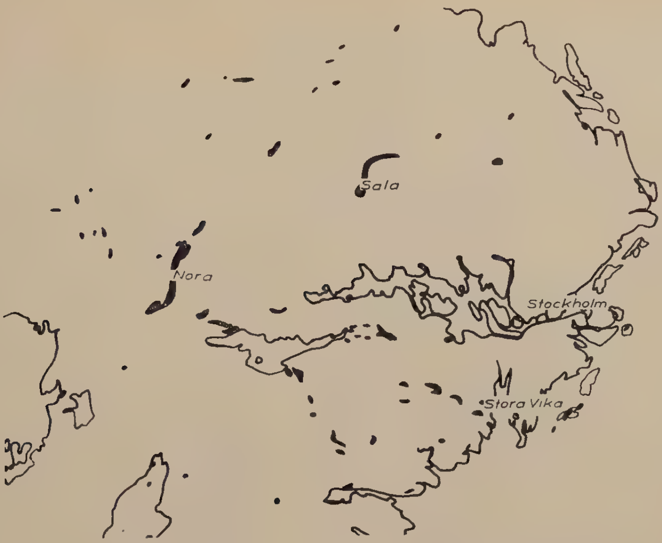

Fig. 1. Occurrence of carbonate rocks in the leptite hälleflint series of Central Sweden.

of metamorphism, and especially the calcite/dolomite ratio between the different deposits. The author considers it probable that the dolomite stones were formed either directly by chemical precipitation in water, or as a result of the dolomitization of sedimentary limestone at an early stage.

Introduction

Stora Vika is situated by Fållnäsviken, about 30 miles to the south of Stockholm (Fig. 1). Skånska Cement, Ltd., began to erect a cement works there, in 1946. As Stockholm and its environs form the largest concentrated market for cement, it was only natural that endeavours were made to locate the new works as near to the capital as possible. There are only comparatively small deposits of Archean limestones in the immediate vicinity of Stockholm. After detailed geological investigations it was found that there was, at Stora Vika, one of the few limestone deposits that satisfied the demands made on raw material for the manufacture of cement.

The deposit is calculated to contain about 50 million tons of limestone down o a depth of 100 m. About 6 million tons have been quarried since the manuacture of cement was begun in 1949. Benching in open cuts, with heavy blasting nd short delay ignition, is the mining method applied at Stora Vika.

Of Sweden's eight cement works, only the two most recently established — Köping 1941 and Stora Vika 1949 — are mining Archean limestone. The others ase their production on younger limestone formations.

Investigations

The limestone deposit at Stora Vika is mentioned in geological literature only in the text to the map of "Nynäs" (Palmgren, 1874).

Professor V. Tanner made the first geological survey of the limestone zone at Stora Vika for Skånska Cement, Ltd., and, together with H. Rudberg, he was also responsible for the first diamond drill holes there. N. Sundius, State Geologist, has made a mineralogical assessment of the suitability of the limestone for the manufacture of cement.

Before the cement works was built and during its erection, some thirty diamond drill holes were made, complemented during recent years by an equal number of holes. The deepest core drill hole is 350 m deep. In addition to diamond drilling, a thousand or so test holes have been drilled near the cutting face, down to a depth of 15 m, and analyses have been made of the drill dust. Professor I. Janelid is superintending the mining, and has, together with the author, planned the latter diamond drilling.

The object of the present investigation has been primarily to study the occurrence of magnesian minerals in the limestone formation. The magnesium content is of practical significance in the manufacture of cement, since a high content of MgO diminishes the constancy of the volume. Swedish regulations of 1960 require that the content of MgO in standard Portland cement may not exceed 5 %. As the limestone at Stora Vika has a rather high MgO-content, careful checks must be made of the magnesium content during the extraction of the limestone and the manufacture of cement.

The author, in order to make a more careful study of the limestone body, has constructed a plexi-glass model of the deposit, scale 1:1000, showing field observations, drill holes, and drill dust analyses. The $CaCO_3$-content of the limestone has been indicated by different colours, and the MgO-contents then shown by transparent screen patterns. It has been possible in this way to distinguish clearly 16 different qualities of limestone. Plexi-glass rods have been used to mark the drill holes. The symbols are protected by transparent plastic piping shrunk, on the rods by heat treatment.

In order to distinguish different minerals in the field, in drill cores and in thin sections, the author has employed staining methods (Högberg, 1950) that make it very easy to distinguish especially calcite and dolomite. It has been possible to determine most of the silicate minerals by solution in acid and separation in heavy liquids.

The blasted and crushed limestone has been subjected to flotation concentration during certain periods, in order to remove minerals containing silicate and magnesium. The tailings have provided suitable material for the study of the

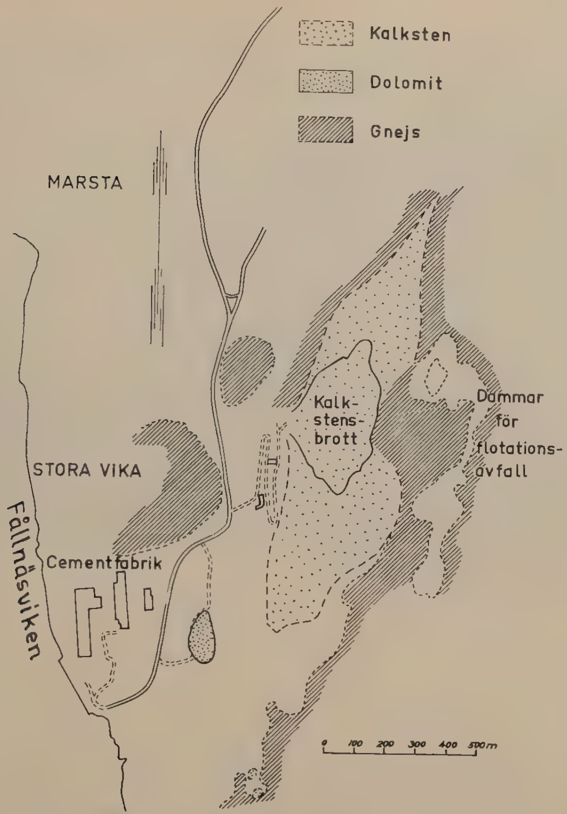

Fig. 2. Geological map of the carbonate rock deposits at Stora Vika. *Kalksten*= limestone, *dolomit*= dolomite, *gnejs*= gneiss, *kalkstens-brott*= limestone quarry.

impurities'' present in limestone. The day-books kept by the cement works make possible to follow — day by day and year by year — the variations in the omposition of the limestone.

Description of the rocks at Stora Vika

The rocks at Stora Vika are included among the Svionian rocks of Central weden. The oldest known rocks within this zone belong to the leptite-hälleflint ries, the lower parts of which consist mainly of volcanic rocks and carbonate ock, which, according to age determinations made recently, are more than 2000 illion years old (Magnusson, 1960). The rocks of the leptite-hälleflint series ere subjected at an early stage to regional compression and folding, at which onsiderable displacement took place, and layers that had formerly been level be-

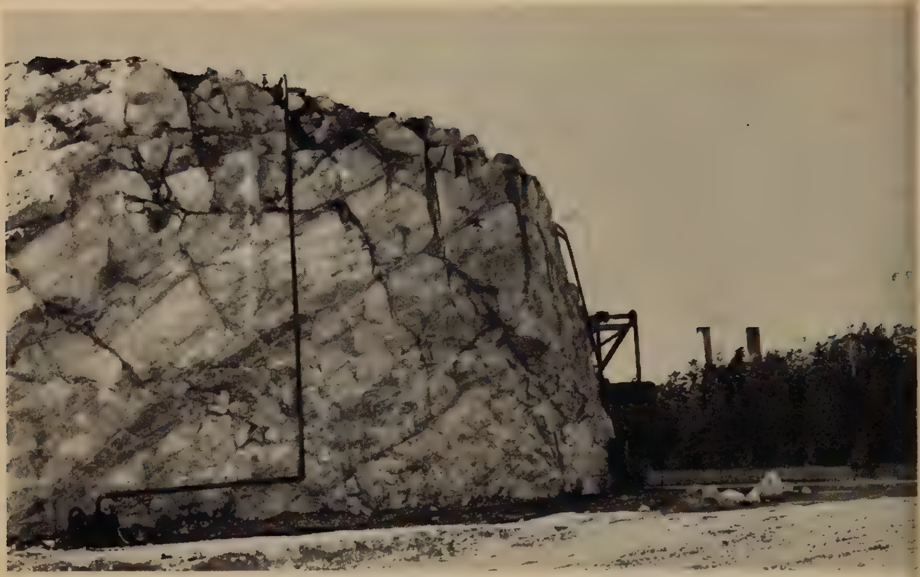

Fig. 3. The southern part of the entrance to the limestone quarry.

came steeply sloping. At the same time, the rock was subjected to recrystallization and became schistose. The increased temperature caused the formation of new minerals by the reaction between the materials originally present or by the introduction of new elements in the form of gases or solutions. The dense limestones were transformed into crystalline rocks. There was a relatively calm period in the development of the crust of the earth after the folding of the leptite-hälleflint series and the appearance of the oldest Archean granites. During this period basic dike rocks penetrated through fissures in the older bedrock. The basic greenstones were transformed into amphibolites when more recent granites and pegmatites appeared in the bedrock. A local increase of temperature occurred again and caused a coarsening of the older rocks. During the post-Archean era there appeared dikes of diabase, which is the youngest of the rocks in the region.

Leptite occurs only to a limited extent at Stora Vika. The dominant rock in the zone is gneiss, in which the limestone body and the leptite remains are present in layers. The limestone body itself is intersected irregularly by granite and pegmatite veins of varying size. There are also local occurrences of dikes of greenstone metamorphosed into amphibolite. A couple of narrow diabase dikes of post-Archean age cut through the limestone body.

The limestone deposit at Stora Vika stretches for 1.5 km from north to south, nd has a maximum width of 400 m (Fig. 2). It dips towards the east at a radient of about 45° (Fig. 3). The limestone is bounded by gneiss on both sides. The boundary between the two rocks can be discerned along the greater part of he eastern side, while in the west it is visible only in the central part. Leptite lso occurs at the boundary to the west. The contiguous rocks have the same trike and dip as the limestone. The limestone body narrows towards the north, nd is only 30 m wide in its most northerly exposed part. To the west and south, he limestone hill slopes rather steeply towards arable land. Limestone slabs in he continuation of the hill southwards suggest that the limestone body continues or another 500 m.

Two hundred metres or so to the west of the southern extremity of the limetone hill is a smaller hill, consisting of dolomite stone. The area between the two arbonate rocks is covered with soil. It is not yet known whether there is any ontact between the two carbonate rocks or what kind of rocks bound the dolonite stone.

Gneiss, which is the most common rock in the region, forms large heights on oth sides of the limestone body except to the south-west, where the country is ow and slopes gently down towards Fållnäsviken. The gneiss is a grey, finely nedium-grained graphite-bearing, veined gneiss. The pale veins in the gneiss are isually more coarse-grained than the other parts of the rock. A chemical analysis f the veined gneiss near the contact with the limestone body gives the following omposition:

SiO_2	64.70 %	Na_2O	2.21 %
TiO_2	0.38 %	K_2O	4.23 %
Al_2O_3	16.45 %	P_2O_5	0.15 %
Fe_2O_3	1.02 %	S	0.05 %
FeO	3.98 %	H_2O	1.35 %
MgO	2.92 %	CO_2	0.60 %
CaO	1.73 %		99.77 %

(drill hole No. 23)

The principal mineral in the gneiss is microcline, but albite and calcareous lagioclase also occur together with this feldspar. Quartz and tremolite are resent in approximately equal quantities. Mica minerals, mainly biotite, lie in arallel strata in bordering layers and give the rock its gneiss-like structure. Great umbers of large reddish-violet garnets are present in the gneiss. The gneiss is ften graphite-bearing, and apatite occurs occasionally.

Carbonate rock is frequently found in direct contact with the gneiss. In some arts of the boundary, the limestone and gneiss are conformly alternately stratified. There is no reaction zone between the two rocks, but the carbonate rock is ften richer in silicate in the proximity of the gneiss, which may also contain bands of carbonate mineral. Small gneiss zones also occur within the limestone body itself.

Magnetic test measurements have shown that it is possible to distinguish between the gneiss and the carbonate rock, but it was impossible to determine the depth of the carbonate rock, which was the purpose of the investigation.

In addition to gneiss, leptite also forms a lateral boundary to the limestone body in some places. There is, in the western part of the extraction area, a zone 25 m wide consisting mainly of leptite and limestone in alternate strata. In the limestone body proper, layers of leptite varying in thickness from 10 to 100 cm, are found running parallel to the limestone strike. The small layers of leptite are often broken, and detached pieces of leptite are not infrequently found in the limestone.

As in the gneiss, no reactions seem to have taken place between the leptite and carbonate rock.

The leptite is grey, evenly grained and stratified, with a grain size of 0.5 to 1 mm. Its principal components are microcline and quartz, with small quantities of biotite and tremolite. Titanite and apatite occur sporadically.

Both the gneiss and the leptite are dominated by potash feldspar.

Greenstone dikes cut across the limestone body in several places. In the southern part of the extraction area are a number of dark-coloured dikes running parallel to the strata of the limestone (Fig. 4). It is highly probable that these greenstone dikes have penetrated through crevices formed when the limestone layers were pressed upwards by orogenic processes. It can be seen clearly that the greenstone dikes have been bent and partly broken up by continued tectonic movements (Fig. 5).

The greenstone dikes, under the influence of these processes, were transformed into amphibolite of a purely gneissic structure. The grain size varies from 0.5 to 1 mm. The principal minerals are hornblende and calcareous plagioclase. The rock is almost black, with occasional pale grains in the dark mass, consisting usually of calcite crystals concentrated to narrow bands parallel to the schistosity.

The limestone in direct contact with the amphibolite is more coarse-grained than otherwise, but apart from that, no reaction zone can be observed between the two rocks.

A chemical analysis of the amphibolite dikes in the southern part of the extraction area shows the following composition:

SiO_2	45,28 %	CaO	11.76 %
Al_2O_3	15.53 %	Na_2O	1.21 %
Fe_2O_3	2.49 %	K_2O	2.88 %
FeO	10.22 %	H_2O	0.32 %
MgO	7.83 %	CO_2	2.34 %
			99.86 %

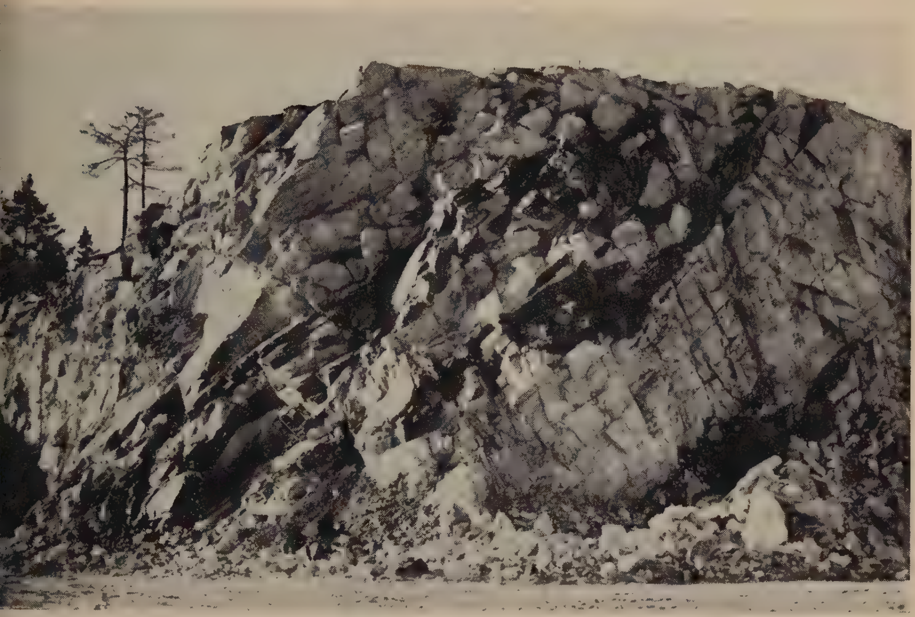

Fig. 4. Dikes of amphibolite in the south-western part of the limestone quarry.

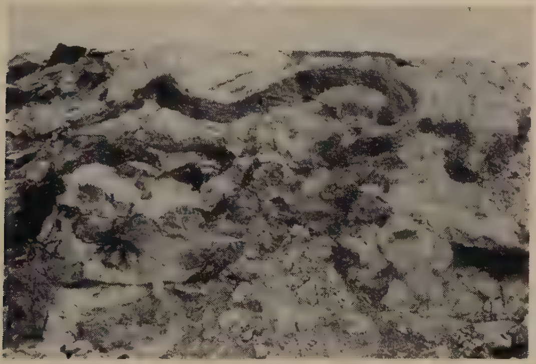

Fig. 5. Folded amphibolite dike in the limestone.

Granites and pegmatites occur rather irregularly in the limestone zone. Owing o their pale colour, they blend with the limestone and are difficult to discern. he colours are always pale, and range from pale blue, semi-transparent quartz o pure white. They may appear as dikes 10 to 100 cm wide, but the most common width is 100 cm. All transitional forms between granite and pegmatite are resent, and grain size varies from a millimetre or so to about two centimetres. chemical analysis of pegmatite from the northern part of the extraction area,

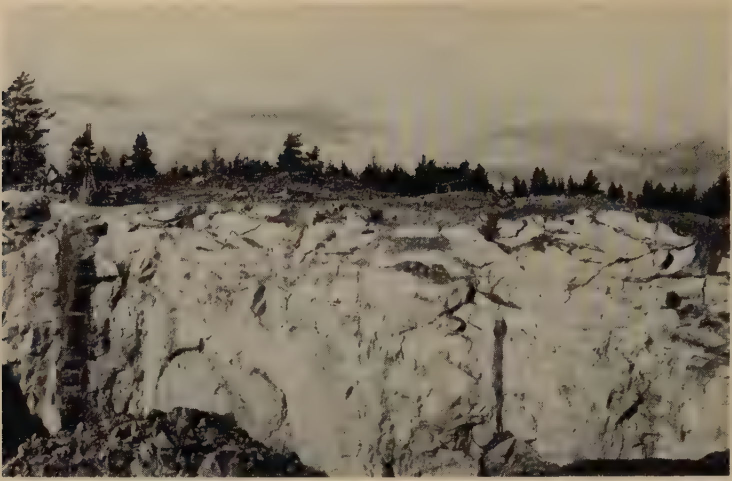

Fig. 6. Diabase dikes crossing the northern part of the limestone quarry.

where the granites and pegmatites occur most frequently, gives the following composition:

SiO_2	72.80 %	Na_2O	3.51 %
Al_2O_3	13.81 %	K_2O	4.42 %
Fe_2O_3	1.50 %	CO_2	1.05 %
MgO	0.57 %		100.04 %
CaO	2.38 %		

(drill hole III: 2, 10.9—11.9 m

Microcline is the most common feldspar in the granite and pegmatite at Stor Vika, together with partly sericitized plagioclase. Quartz and biotite, most ofte chloritized, are also essential minerals. Zircon, zoisite, apatite, and titanite occu as accessory minerals.

At the contact between limestone and granite or pegmatite, there is usually reaction zone one or two millimetres wide. This zone is composed principally o clinozoisite, poor in iron, and to a smaller degree of diopside-pyroxene. The limestone has become markedly coarse crystalline at the contact.

Diabase dikes occur in the northern part of the limestone zone. They ar about 50 cm wide and run in a north-westerly direction, cutting through bot gneiss and limestone and also granite. Thus the diabase is the most recent roc in the region. The contact between the diabase dikes and the other rocks i sharp, and no reaction seems to have taken place with the limestone (Fig. 6).

The observations of the bedrock at Stora Vika are in good agreement with th latest descriptions of the Svionian rocks of Central Sweden (*e.g.* Magnusso 1960).

Definitions

The term 'carbonate rock' is used here about rocks containing more than 50 % arbonate mineral, and the term 'dolomite stone' is used about a carbonate rock onsisting mainly of the carbonate mineral dolomite.

There are a number of classifications of carbonate rocks with a successively ncreasing content of magnesium. The best-known classifications are those of ayeux (1935), which have been accepted with slight amendments by Pettijohn 1949) and Rodgers (1954):

Term	Carbonate mineral	
	calcite	dolomite
Limestone	>95 %	< 5 %
Magnesian limestone	90—95 %	5—10 %
Dolomitic limestone	50—95 %	10—50 %
Calcitic dolomite stone	10—50 %	50—90 %
Dolomite stone	<10 %	>90 %

Since it is far simpler to determine the ratio Ca/Mg than the ratio calcite/ olomite, the above table has, keeping the classification, been converted to refer o the ratio Ca/Mg.

	Ca/Mg
Limestone	>57
Magnesian limestone	57—29
Dolomitic limestone	29—5
Calcitic dolomite stone	5—2
Dolomite stone	<2

hilingar (1957) has suggested a classification of carbonate rocks based on the a/Mg ratio. His classification includes two more groups, but otherwise con- orms, on the whole, to the above table.

The Ca/Mg ratio, which can be rapidly obtained by the titration of the part f the carbonate rock soluble in acid, gives in most cases a sufficiently exact value or the classification of a carbonate rock. A really quantitative division of the arbonate mineral in calcite and dolomite can only be obtained by X-ray deter- inations or by time-consuming optical determinations.

The theoretical value of Ca/Mg in dolomite stone is 1.65 and in limestone ∞.

A determination of the Ca/Mg ratio in Swedish carbonate rocks gives the ollowing approximative values:

	Ca/Mg
Archean limestone	1.7—500
Orthoceras limestone	30—200
Silurian limestone	40—200
Cretaceous limestone	40—300

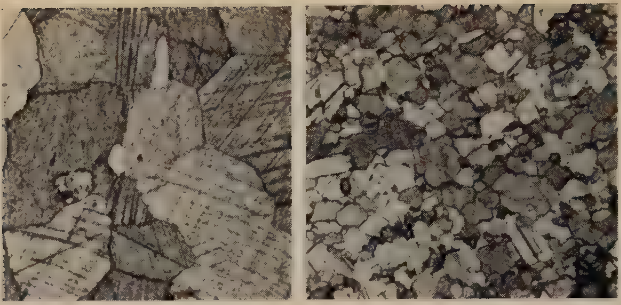

Fig. 7. Comparison of grain size of limestone (left) and dolomite stone (right) at Stora Vika. × 5

Archean limestone thus embraces all the five groups in the classification, from pure limestone to pure dolomite stone. The other limestone formations contain only the groups limestone and magnesian limestone.

Description of the carbonate rocks

Carbonate rocks with varying contents of magnesium occur at Stora Vika. The limestone hill consists, according to the terminology used here, mainly of dolomitic limestone and magnesian limestone. Pure limestone is present only in small quantities. The smaller hill, called the dolomite height here, consists, according to the classification, of a calcitic dolomite stone. The area between the two heights is covered with soil and has not yet been investigated. The carbonate rocks in the two hills will be described in greater detail below.

The dolomite height

The dolomite height situated 200 metres to the west of the southern point of the limestone hill (Fig. 2) is about 200 m long and 100 m wide. The rock is exposed at several spots on the wooded height, especially to the west, where the hill rises steeply about 15 m above the surrounding land. No contacts with latera rocks have been found in this smaller carbonate rock region. Leptite bands 20 cm wide and pegmatite dikes 2 m wide were found in the three core drill holes made there.

The dolomite stone is pale with tinges of grey and blue. The rock is fine-grained with grain sizes varying from 0.2 to 1 mm, distinctly finer grained than the limestone extracted for the manufacture of cement (Fig. 7). Cores a metre long were often obtained by drilling, which seldom happened when drilling in the limestone hill. The dolomite stone is marble-like and often contains spots and enses of green minerals. Pale bands of mica minerals also often occur in the tone.

An average analysis of the carbonate rock in the dolomite height gives the ollowing composition:

SiO_2	6.0 %	CaO	32.5 %
Al_2O_3	1.3 %	CO_2	40.5 %
Fe_2O_3	1.1 %		99.5 %
MgO	18.1 %	Ca/Mg	2.1

Thus, according to the classification, the carbonate rock in the dolomite height s a calcitic dolomite stone.

It can be calculated from the chemical analysis that the carbonate content of he rock does not exceed 90 %. Thus the content of non-carbonate minerals hould be at least 10 %. When it can be seen clearly by staining methods that he rock consists mainly of dolomite stone with a small amount of calcite, the arbonate content declines somewhat. Calculations based on the chemical analysis how that the rock has approximately the following composition:

Dolomite	67 %
Calcite	20 %
Silicate	13 %
	100 %

Further calculation shows that the silicate in the carbonate rock consists main- y of magnesian silicate. Microscopic studies of thin sections and chemical ana- ysis of isolated grains of mineral have revealed that the silicate minerals occur- ing most commonly in the dolomite stone are forsterite and phlogopite. The nagnesian olivine mineral forsterite occurs usually as green spots, 1—2 mm in liameter, in the denser mass (Fig. 8). The green spots are often concentrated n bands 10 cm wide, running parallel to the strike. The forsterite minerals occur oth pure and changed into serpentine.

The magnesian mica mineral, phlogopite, also forms bands in the dolomite tone, but usually occurs rather frequently as single grains distributed evenly in he rock. Sometimes the phlogopite mineral is chloritized. Diopside and cum- ningtonite are found among the other silicate minerals. Grains of quartz and arnet can also be observed occasionally, as well as sulphide minerals.

The rock in the dolomite height is, as mentioned above, a calcitic dolomite tone with a calculated calcite content of ca. 20 %. The use of staining methods nakes is possible to study the occurrence of the calcite minerals in the dolomite tone. It can be seen that as a rule the grains of calcite form agglomerations of to 10 grains (fig. 9). Such concentrations of grains of calcite are often larger

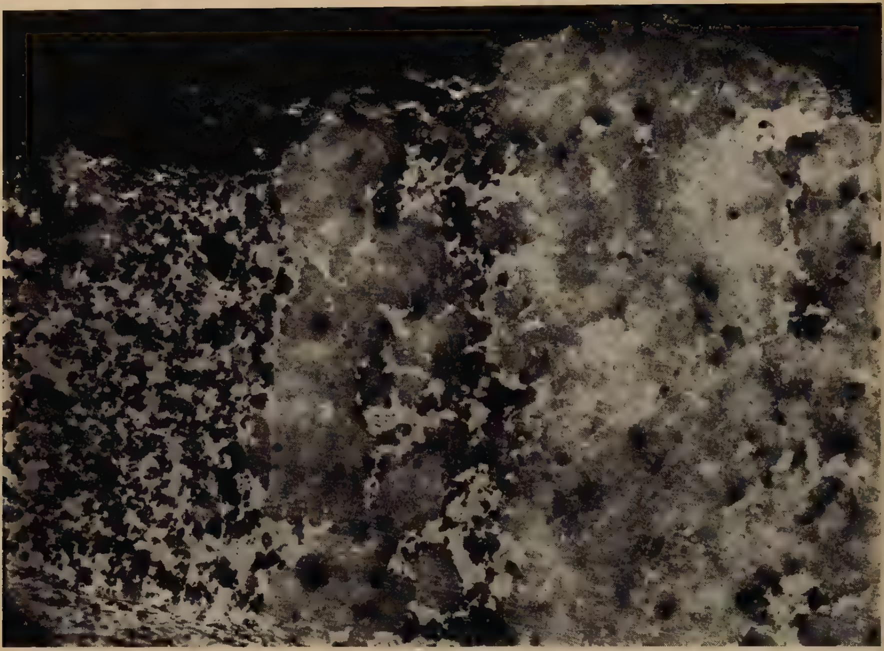

Fig. 8. Forsterite band in dolomite stone. The irregular, pale figures in the vicinity of the dark grains are calcite, made more distinct by staining.
× 2

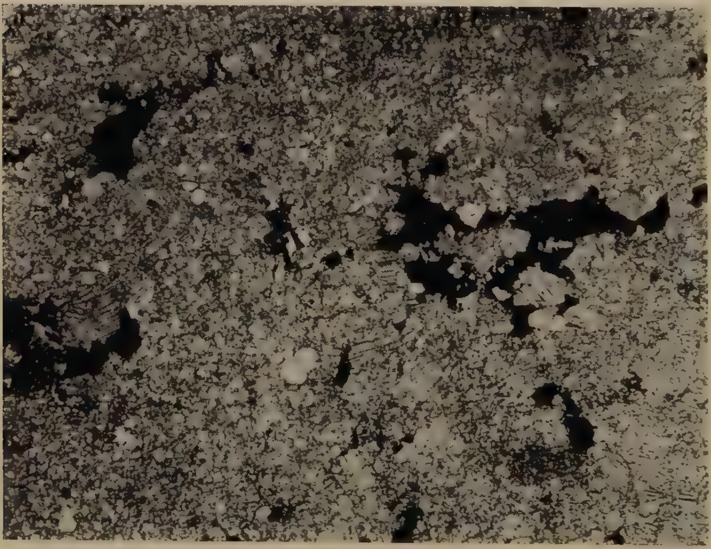

Fig. 9. Calcite inclusions (black) in the dolomite stone.
× 5

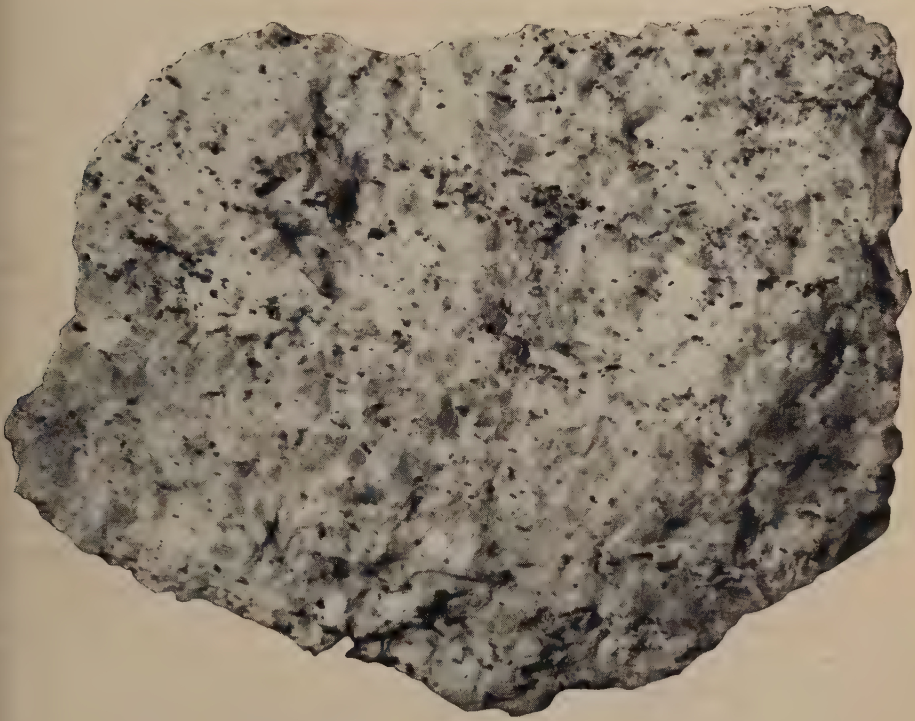

Fig. 10. Typical limestone from Stora Vika. The dark minerals are phlogopite. Colourless diopside is also present in large quantities, but does not appear in the photograph. $^1/_2$ ×

than those of the dolomite crystals. Calcite always occurs more richly together with the olivine minerals present in dolomite stone than otherwise. There seems to be a marked relationship between the content of forsterite and that of calcite (Fig. 8).

Calcite is also found filling the fissures of the dolomite stone. The crystals are larger there than in the other parts of the rock.

The limestone hill

The limestone hill is about thirty times as large as the dolomite height, and contains carbonate rocks of varying appearance and composition. Limestone is extracted from this hill in large open-cast workings for the manufacture of cement. The soil has been removed from around the workings, and the hill is also bare in large parts of the area. To the west and south the limestone rock rises rather steeply to a height of about 50 m above the surrounding country.

The colour of the carbonate rock varies from pure white to grey. The greater part of the area contains a medium- and even-grained rock with a grain size of 2 to 5 mm (Fig. 10). Both finer-grained and coarser-grained carbonate rocks occur in small zones, but it is only exceptionally that rock is found with a grain as fine as that in the dolomite height. The coarse-grained limestones are often found in association with pegmatite and amphibolite dikes.

The carbonate content of the limestone hill is mainly between 70 and 90 %. Purer zones occur in some places, and there are others with a lower carbonate content. The latter often contain inclusions of leptite and pegmatite. The magnesium content varies, and according to the classification, the limestone hill consists of approximately equal parts of dolomitic limestone and magnesian limestone.

It has been found by exploration drilling and during extraction that the southern part of the extraction area has higher contents of carbonate and magnesium than the northern part. This has practical significance, since the limestones in some parts of the southern region have a too high magnesium content to allow them to be used directly in the manufacture of cement. By mixing stone with a high magnesium content from the southern part with magnesium-poor stone from the northern part, the deposits can be exploited more economically.

An average analysis of the extracted limestone gives the following composition:

SiO_2	13.5 %	Na_2O	0.2 %
Al_2O_3	4.1 %	K_2O	0.8 %
Fe_2O_3	0.5 %	S	0.1 %
FeO	0.4 %	CO_2	35.0 %
MgO	2.5 %		100.1 %
CaO	43.0 %	Ca/Mg	20

This analysis is, according to the classification, equivalent to a dolomitic limestone.

It can be calculated from the chemical analysis that the carbonate content cannot exceed 80 %. Thus the content of non-carbonate minerals should be at least 20 %, *i. e.* the content of silicate minerals is about twice as high in the limestone hill as in the dolomite height. By the use of staining methods, it can be established that the carbonate minerals of the rock consist mainly of calcite, but that dolomite crystals occur sporadically. The following average composition of carbonate rock from the limestone hill can be calculated:

Calcite	74
Dolomite	5
Silicate	21
	100

According to this calculation of the relationship calcite/dolomite, the average analysis of the extracted limestone would, according to the classification, be included in the group magnesian limestone. This difference in classification is due o the fact that the carbonate rock contains relatively large amounts of calcium- and magnesium-silicate.

To elucidate further the composition of the carbonate rock calculated from chemical analyses, the part of the rock insoluble in diluted hydrochloric acid has been analyzed from average samples from the northern and southern parts of the workings:

Insoluble in diluted hydrochloric acid	North	South
SiO_2	60 %	53 %
Al_2O_3	11 %	8 %
Fe_2O_3	1 %	1 %
CaO	12 %	17 %
MgO	8 %	18 %
Na_2O+K_2O	7 %	3 %
	99 %	100 %

Through elimination in diluted hydrochloric acid, the carbonate mineral is expelled in the first place, but also part of the calcium- and magnesium-silicate. Nevertheless, comparison gives a good idea of the differences in the minerals pre-ent in the two parts of the extraction area. The alkali content is much higher in he northern than in the southern part of the workings, which suggests the presence of feldspar and mica minerals. The feldspars usually originate from lep-ite and pegmatite inclusions in the carbonate rock. The mica, on the other hand, occurs in rather large quantities in the carbonate rock itself. The magnesium con-ent is considerably higher in the southern than in the northern part of the workings, which implies a somewhat higher content of magnesian silicate mineral.

The northern part of the deposit, which has, on an average, lower carbonate and magnesium contents than the southern part, is narrower and bounded on both sides by gneiss. Granite and pegmatite zones are also more frequent there han in the southern part.

It can be seen very clearly on the walls of the limestone workings that the arbonate rock is parallelly structured (Fig. 11). Alternate pale and somewhat darker bands of varying width, dip towards the east at a gradient of 40—60°. The darker bands may, in some cases, consist of pale grey leptite banks, but as a rule they are shades of colour in the carbonate rock itself, caused by a con-entration of coloured silicate minerals. It is chiefly mica minerals that occur in bands of narrow stripes. Mica, occurring in parallel lines, is also present in the ale parts of the carbonate rock. In addition to mica, green or yellow olivine minerals often occur concentrated in distinct zones, parallel to the strata of the arbonate rock (Fig. 12).

It is primarily the coloured silicate minerals that characterize the carbonate ock, even though the content of pale silicate minerals is not small. In all parts f the limestone hill, there can be observed a pale yellowish-brown or brown mica

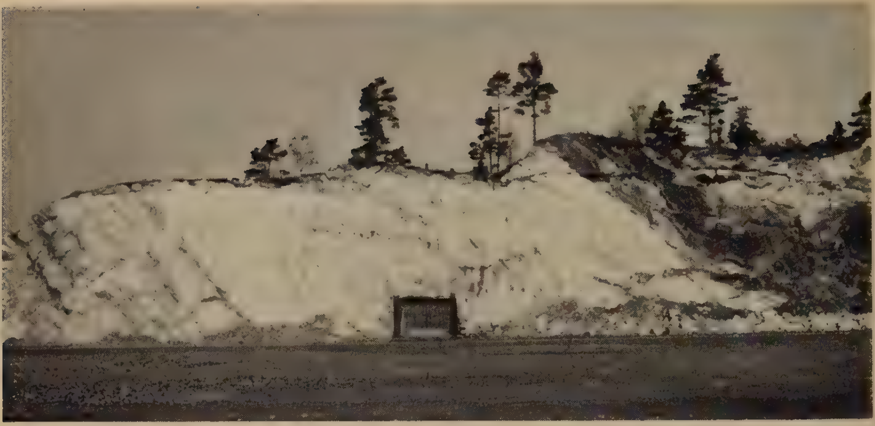

Fig. 11. The northern part of the limestone quarry.

mineral, which has, by chemical analyses, been found to be phlogopite. A faint grey diopside-pyroxene is almost as common as phlogopite (Fig. 13). Olivine, mainly forsterite, is present in large quantities in the whole deposit; the grains are often green, but may also be the same colour as the carbonate rock. The coloured olivine minerals are usually transformed partly into serpentine.

Phlogopite, diopside, and forsterite are the most important silicate minerals in this zone, but magnesian hornblendes and biotite are also common (Fig. 14).

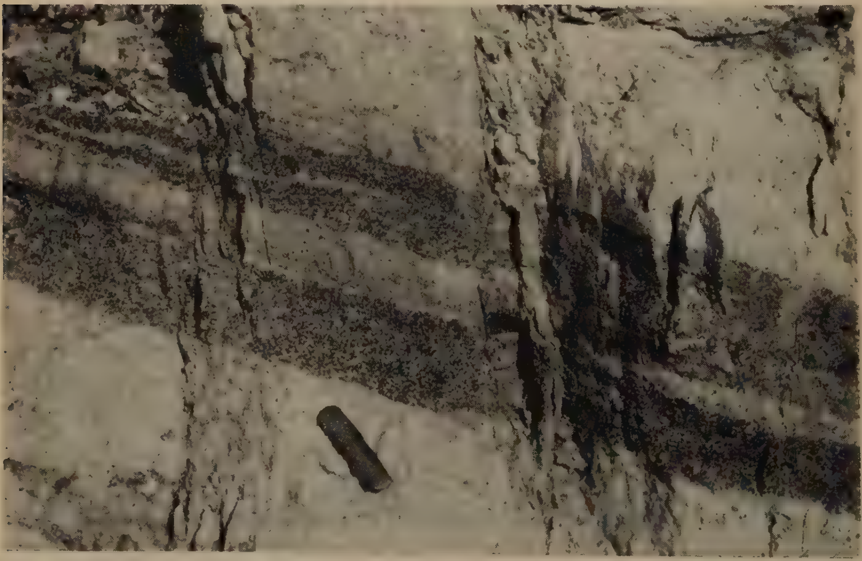

Fig. 12. Skarn bands in the limestone. The bands are speckled green with forsterite. Dolomite often occurs in connection with the skarn bands.

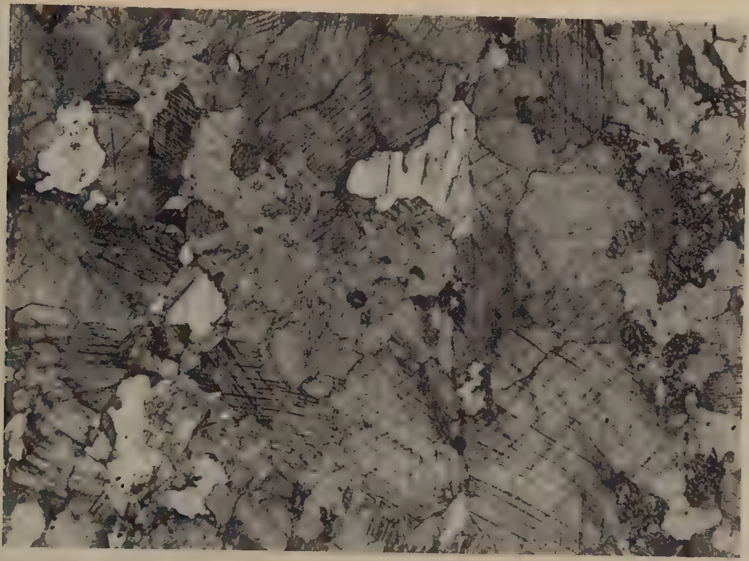

Fig. 13. Limestone with phlogopite and diopside minerals.
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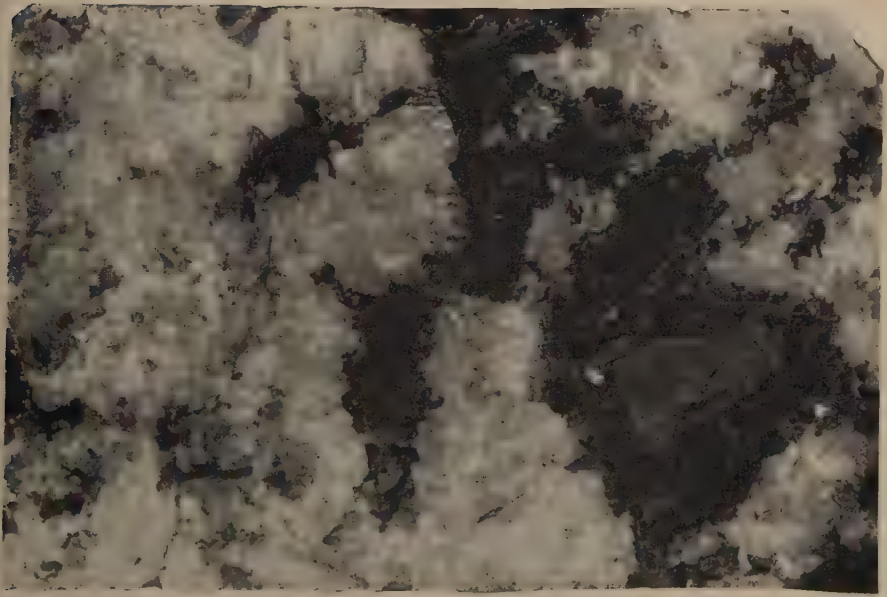

Fig. 14. Biotite concentration in limestone drill core.
2 ×

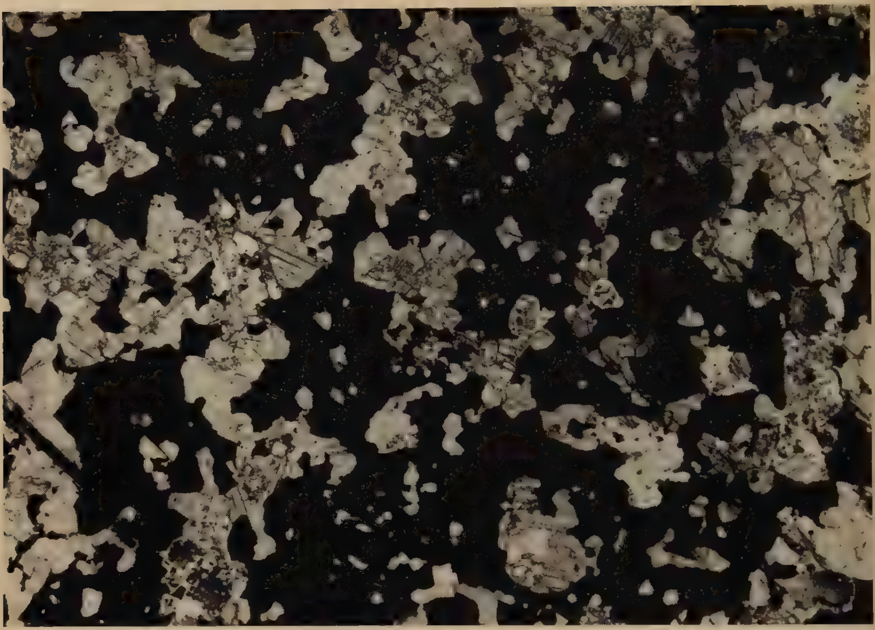

Fig. 15. Dolomite crystals in limestone at Stora Vika.
× 5

Grains of quartz and feldspar are not uncommon either. Sphalerite is the most common ore mineral.

The magnesium content of the carbonate rock originates partly from the silicate minerals already mentioned, phlogopite, diopside, forsterite, and serpentine but some magnesium comes from dolomite. By staining methods and optical determinations, it has been demonstrated that the carbonate rock in the limestone hill contains dolomite crystals (Fig. 15). A large number of drill cores and samples from the workings were examined to determine the occurrence of dolomite in the limestone. It was found that dolomite did not occur generally in the deposit, although, according to the classification of the carbonate rock as dolomitic limestone, this was to be anticipated. Most dolomite was present in the samples with the highest content of magnesium. The dolomite crystals were almost without exception, concentrated to zones of carbonate rock containing numerous bands of forsterite or phlogopite minerals, parallel to the strata of the carbonate rock. These zones, rich in both dolomite and magnesian silicate, occur sporadically all over the deposit, but are most frequent in the southern part o the limestone hill. The zones rich in magnesium are not usually very large, and are therefore more difficult to localize by drilling. In the workings, however, the green-speckled bands are easy to distinguish (Fig. 12).

The dolomite height and the limestone hill differ in many respects. The limestone hill is about thirty times as large as the dolomite height, and contain several different carbonate rocks. The carbonate rocks in the limestone hill are largely surrounded by gneiss, and there are numerous inclusions of granite and pegmatite, which is not the case in the dolomite height.

The rocks differ mainly on account of the grain size (Fig. 7). The dolomite stone has a much finer grain than the other carbonate rocks, and is also a shade darker. Core drilling showed that the dolomite stone has greater cohesion, and the chemical analysis suggested a lower content of silicate minerals than in the other parts of the deposit.

In the dolomite height the content of MgO is high and almost constant. In the limestone hill the content of MgO varies greatly, but the highest found value is only half as high as in the dolomite height.

Of the magnesian silicate minerals, phlogopite, forsterite, and serpentine occur in about equal quantities in both regions, while diopside occurs mainly only in the limestone hill.

Calcite is present in the dolomite stone distributed rather evenly, but is enriched in the stripes or bands of olivine and mica material occurring in the rocks. In the limestone hill, dolomite is present only in restricted areas rich in olivine and mica minerals. The dolomite crystals are about the same size as the calcite crystals and are therefore much larger than the grains of dolomite in the dolomite stone.

The dolomite is concentrated to the same zones of olivine and mica minerals in the limestone hill as calcite in the dolomite height.

The flotation plant

There is a flotation plant at the cement works at Stora Vika, intended primarily to remove the magnesium minerals from the limestone. Flotation concentration of limestone had not been practised earlier in Sweden.

The flotation plant at Stora Vika is constructed so that the crushed and ground limestone passes through centrifuges, which classify the limestone sludge into two almost equal fractions. The coarse fraction, 0.03—0.2 mm is subjected to froth flotation, while the fine fraction < 0.03 mm is pumped direct into sedimentation tanks, where the water content is reduced. There are two reasons why the fine sludge is not subjected to flotation; it has a higher carbonate content than the coarse fraction, and it requires greater amounts of flotation reagents. Flotation of the coarse goods is carried out in 18 cells placed in two batteries. From the first 6 cells in both batteries, an overflow is obtained consisting of a concentrate of pure limestone pulp, which is pumped into sedimentation tanks. From the last three cells an intermediate product is obtained, which returns to the flotation plant. The bottom substance consists of waste, containing a relatively large amount of silicate minerals. This waste is pumped into natural ponds to the east of the limestone hill.

The reagents used in flotation have been sulphate soap as frothing reagent, fuel oil as collector and silicate of potassium as "depressant" to prevent the froth adhering to the waste mineral. Owing to the difficulties caused by the formation of froth in the sedimentation tanks, only one half of the limestone extracted could pass through the flotation plant, and since only the coarse fraction was concentrated by flotation, not more than 25 % of the limestone entering the works was subjected to flotation. As it is possible to extract the limestone selectively, the concentrator was only employed during certain periods. A year or so ago it was closed down.

An extract from a report on the work of the concentrator in February 1958 gives the following values:

	Weight %	Carbonate content %
Incoming limestone	100.0	71.3
To the concentrator	31.9	69.2
Fine fraction	12.8	74.5
Coarse fraction	19.1	65.6
Concentrate	14.1	83.8
Waste	5.0	14.4
Final product to the cement works	95.0	74.3

The above table shows that it is possible by flotation to increase the carbonate content from 65.6 to 83.8 %. The circumstance that the final product had not a higher carbonate content is due to the fact that only 19 % of the incoming limestone was really concentrated. The table shows too that the fine fraction had a considerably higher carbonate content than the coarse fraction, which is because the grains of carbonate disintegrate when crushed and ground, more easily than silicate minerals.

Chemical analyses of the material from the flotation plant show roughly what happens during this process.

Flotation material

	Incoming coarse goods for flotation 100 %	Concentrate 65 %	Waste 35%
$Si0_2$	23.4	6.1	49.5
Al_20_3	3.5	1.4	12.4
Fe_20_3	1.0	0.7	0.9
$Mg0$	2.9	2.5	5.1
$Ca0$	38.2	49.7	19.3
K_20	1.0	0.2	3.3
Na_20	0.3	0.1	0.4
Ignition losses	29.2	39.1	9.1
	99.5	99.8	100.0

The table shows that, in the first place, SiO_2, Al_2O_3 and K_2O are removed from the limestone by flotation. The magnesium content has been reduced somewhat, but as less than 25 % of the limestone was concentrated, the actual reduction of the magnesium content was insignificant. The iron content was almost unchanged. The tailings contained about 20 % carbonate.

A mineralogical, quantitative determination by the point counter method of two samples from the tailings ponds, gave the following compositions of non-carbonate minerals:

Mineral	Sample No. 1	Sample No. 2
Feldspar	38 vol. %	45 vol. %
Quartz	21 » %	20 » %
Pyroxene	16 » %	17 » %
Mica	10 » %	8 » %
Serpentine	13 » %	5 » %
Olivine	0 » %	1 » %
Others	2 » %	3 » %
	100 vol. %	100 vol. %

If the carbonate mineral is ignored, the tailings from the flotation plant consist up to about 60 vol. % of feldspar and quartz. Potassium feldspar and plagioclase are present in almost equal quantities. As the carbonate rock contains only very small amounts of feldspar and quartz, these minerals must originate from the gneiss, leptite, and pegmatite inclusions in the limestone, which cannot be removed during extraction. The other minerals come mainly from the carbonate rock, above all the typical mica mineral, phlogopite, which characterizes the tailings.

The flotation method employed does not remove dolomite, only silicate. The most important magnesium silicates removed during flotation are diopside, phlogopite, and serpentine. There is a remarkably small amount of olivine in the tailings, seeing that the carbonate rock contains numerous bands of such minerals.

Contact and regional metamorphism

In the orogenic processes that took place in association with the folding of the eptite-hälleflint series and the appearance of Archean granite, the older rocks were subjected to regional increases of temperature and pressure. This caused . coarsening and recrystalization of the carbonate rocks into crystalline rocks. At he same time reactions took place between the carbonate mineral and impurities n the carbonate rock by which different silicate minerals were formed.

It has been found in the metamorphism of carbonate rock that, with each uccessively higher temperature at a given pressure, a series of minerals is formed, each of which characterizes a definite phase in the progressive decarbonization process. Eskola (1922) was the first to determine four different stages in the metamorphism of magnesian limestone in western Massachusetts. The four steps in metamorphism are indicated by four minerals: quartz, tremolite, diopside and wollastonite. Later Bowen (1940), in studies of the system $CaO-MgO-SiO_2-CO_2$ in dolomitic and magnesian limestone, found thirteen different steps distinguished by ten mineral phases. The number of metamorphism steps has been increased by Tilley (1951) to seventeen and the mineral phases to thirteen as follows:

1. Talc
2. Tremolite
3. Forsterite
4. Diopside
5. Periclase
6. Wollastonite
7. Monticellite
8. Akermanite
9. Tilleyite
10. Spurrite
11. Rankinite
12. Merwinite
13. Larnite

Weeks (1956), by studies of the thermo-chemical equilibriums of minerals formed in the metamorphism of dolomite stone, has found that the assessed equilibrium curves are in good agreement with those plotted experimentally. The reaction steps advanced by Weeks differ from the series of Bowen and Tilley in that diopside becomes stable before forsterite, and wollastonite before periclase.

According to Bowen, it is not usual for the diopside stage to be passed in regional metamorphism. In contact zones around the emerging granites, there is a somewhat higher temperature, whereby the wollastonite step can be reached, but not passed. The higher degrees of metamorphism are not reached until the temperatures that can arise at contact with basic magmas are attained.

The recrystallization and coarsening of the carbonate minerals at Stora Vika were caused by regional metamorphism. With the intrusion of pegmatites and granites into the carbonate rock, a further coarsening of the carbonate minerals occurred in the immediate vicinity of the intrusion. This latter contact metamorphism also formed a reaction zone, two millimetres thick, characterized by a rich occurrence of clinozoisite. An equivalent reaction zone between pegmatite and limestone in the Mansjö region was described in detail by von Eckermann (1922).

The impurities in the originally sedimentary limestone have very probably consisted of silicic acid and clay minerals. In the metamorphism of the carbonate rock at Stora Vika, mainly forsterite and phlogopite were formed in the dolomite areas, and diopside and phlogopite in the calcite regions.

The magnesian limestone at Stora Vika has thus very probably passed through the first stages of progressive decarbonization, during which, according to Bowen the following equilibrium reactions may have occurred:

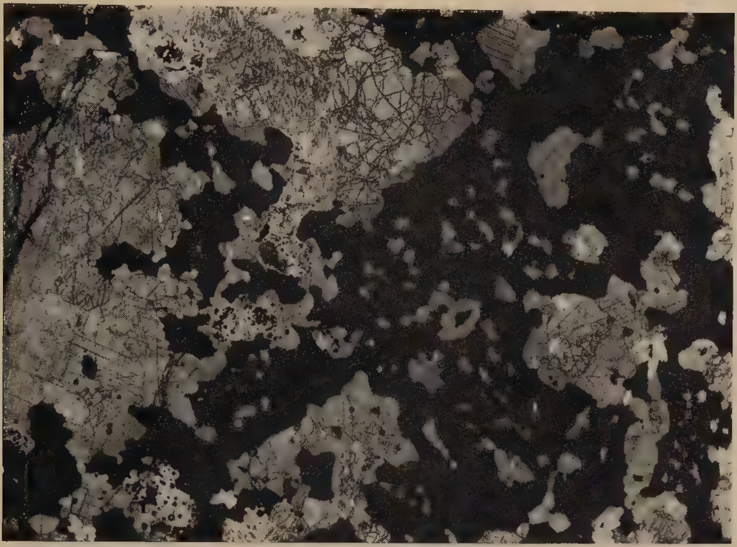

Fig. 16. Forsterite mineral surrounded by dolomite and calcite.
The calcite crystals are stained black.
× 5

(a) 3 dolomite + 4 $SiO_2 \rightleftarrows$ tremolite + 2 calcite + 4 CO_2
(b) tremolite + 5 dolomite $\rightleftarrows$ 6 calcite + 4 forsterite + 4 CO_2
(c) tremolite + 2 calcite + 2 $SiO_2 \rightleftarrows$ 3 diopside + 2 CO_2

The magnesian silicate minerals, diopside and forsterite, may thus have been formed in the carbonate rock at Stora Vika without the introduction of material from outside.

The mica mineral, phlogopite, is the most common mineral in the carbonate rocks at Stora Vika. This mineral does not indicate any definite rise in temperature.

Forsterite, which is present in great quantities in the dolomite stone at Stora Vika, nearly always occurs together with calcite, which is confirmed by reaction (b) (Fig. 16).

Ca/Mg ratio

The Ca/Mg ratio in limestones and dolomite stones has been considered by Daly (1909) and Chilingar (1953) to depend on the age of the carbonate rocks, *i.e.* the occurrence of dolomite stones declines successively with time. Later Chilingar (1956) found that no simple connection exists between the age of carbonate rocks and the Ca/Mg ratio. Dolomite stones and limestones have a cyclical occurrence, which Chilingar assumes to be due to a gradual accumulation of magnesium in sea water, until suitable conditions appear for the precipitation of dolomite. The rich occurrences of dolomite stones during pre-Cambrian time are considered by Russian workers (Strakhow, 1958) to be due perhaps to a higher CO_2 pressure prevailing during that era, which encouraged the formation of dolomite.

Chemical analyses of carbonate rocks from America and Europe show, according to Chilingar, that the great majority of the carbonate rocks have a Ca/Mg ratio of < 2 and limestones > 32. Thus successive transitional forms from pure dolomite stone to limestone are lacking.

The Ca/Mg ratio at Stora Vika is not measured directly on the calcite/dolomite ratio, since the carbonate rocks usually contain a relatively large amount of calcium-magnesian silicate mineral. The table below gives the contents of Ca and Mg in the essential minerals in carbonate rocks.

Mineral	Ca %	Mg %
Calcite	40	0
Dolomite	22	13
Diopside	18	11
Phlogopite	0	17
Forsterite	0	34
Serpentine	0	26

As the table shows, forsterite and serpentine have the highest magnesium contents. Phlogopite, which is of rich occurrence in the carbonate rocks, has a higher content of magnesium than dolomite.

Magnesium may also be present in solid solution in the calcite lattice and be in equilibrium with dolomite (Graf & Goldsmith, 1955, Harker & Tuttle, 1955, Goldsmith, 1960). The occurrence of magnesium in solid solution in metamorphic limestone formations has been demonstrated by means of X-ray analyses by Goldsmith, Graf & Joensuu (1955). This study did not determine whether magnesium also occurs in solid solution in the calcite crystals in the limestone at Stora Vika. Calculations of the mineralogical composition of limestone show that the greater part of the magnesium content is bound as silicate. Only a small part can occur as dolomite or as magnesium in solid solution. Since it has been shown that dolomite crystals are present in the limestone, only a relatively small part of the magnesium content can be present in solid solution.

Dolomite can be formed from magnesium in solid solution in the calcite lattice, and has then at first the same crystallographic orientation as the calcite (Goldsmith, 1960). Only an insignificant amount of calcium can occur in solid solution in dolomite.

The Ca/Mg ratio in the dolomite height at Stora Vika is almost constant

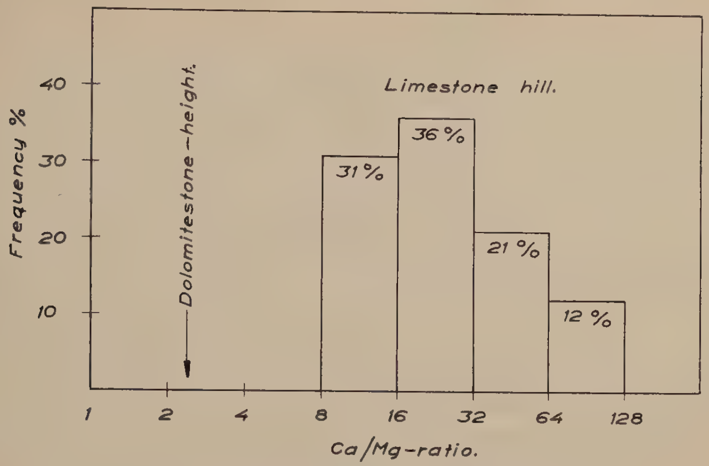

Fig. 17. Frequency diagram of the Ca/Mg ratio in the carbonate rocks at Stora Vika.

between 2.0 and 2.5 %. The calcium content comes from dolomite and calcite, while the magnesium content originates from dolomite and the silicate minerals, phlogopite, forsterite, and serpentine.

In the limestone hill, the Ca/Mg ratio varies from 10 to 125, which means that there are several different types of carbonate rocks in this region. The average value for Ca/Mg is 20.

The frequency diagram (Fig. 17) shows that there is an interval in the Ca/Mg ratio between the dolomite height and the limestone hill. The highest Mg-content in the analyses from the limestone hill is only half the average value of those of the dolomite height. The diagram also shows that almost 70 % of the carbonate rock in the limestone hill can be designated dolomitic limestone, 20 % magnesian limestone and ca. 10 % pure limestone.

To investigate whether the magnesium content is due to the degree of purity of the carbonate rock, a frequency table has been drawn up, based on some 2000 chemical analyses of samples from the limestone hill.

Frequency table

		Mg O %				
		0—1	1—2	2—3	>3	Σ
Carbonate %	50—60	1	0	0	0	1
	60—70	2	3	0	2	7
	70—80	5	6	7	4	22
	80—90	9	20	16	7	52
	>90	4	4	3	7	18
	Σ	21	33	26	20	100

The content of carbonate determined by titration and calculated as $CaCO_3$.

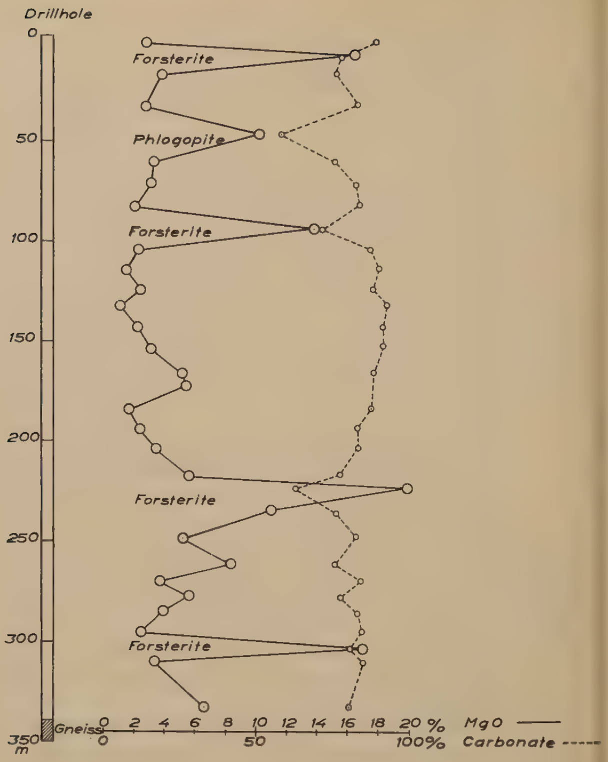

Fig. 18. Distribution of magnesium in a drill hole in the limestone hill.

The table shows, in the first place, that the carbonate content of practically the whole limestone hill is above 70 %. The four classes with a successively increasing content of magnesium seem to be represented equally in the deposits. The highest magnesium content is found in the purest carbonate rock, however.

In order to illustrate more clearly the variations in the magnesium content in a local area, a diagram has been drawn of the deepest drill hole, drilled vertically 350 m in the southern part of the limestone extraction area.

The diagram (Fig. 18) shows that the magnesium content has a number of peaks rising from a rather even base. A slight reduction of the carbonate content can be discerned at several peaks. A study of the drill cores reveals that four of the five clearly marked maximum values of the magnesium content have been caused by a very markedly green-speckled carbonate rock. The green mineral has been found to be forsterite. The carbonate rock at the remaining rather lower peaks of the magnesium curve is rich in phlogopite. Staining the drill cores revealed that the concentration of the magnesian silicate is also accompanied by an enrichment of the dolomite (Fig. 16).

The same tendency towards a rise in the magnesium content is found in the ther drill holes, where the carbonate rock is speckled with green. In spite of a ich occurrence of olivine mineral, the carbonate content sinks only slightly.

In order to get a rough idea of the dolomite content of the limestone, the nagnesium content soluble in diluted hydrochlorid acid has been determined in large number of samples in comparison with the total content. As the magneium silicate is partly soluble in acid, it is possible by this method of analysis to btain only a maximum value of the dolomite content, on the assumption that he whole of the magnesium soluble in acid is carbonate bound. The analyses how that at least two-thirds of the total MgO-content is silicate bound and ne-third, at the most is, carbonate bound.

Since the carbonate rock in the limestone hill contains on an average 2.5 % 1gO, a maximum of 0.8 % MgO is bound as carbonate, which is equivalent o an average value of 3.5 % dolomite. On the same assumption the highest lolomite content found in the limestone hill is 30 %.

By studying drill cores and specimens from the limestone workings with the elp of staining methods, the author has found that as a rule dolomite occurs nly in certain restricted zones in the limestone hill, characterized by the preence of large amounts of olivine minerals, so-called skarn bands (Fig. 12). Dolomite crystals are found only sporadically in other parts of the limestone area.

The author has also found, with the help of staining methods, a general ccurrence of calcite crystals in the dolomite stone, as a rule in association with he equally common olivine minerals (Fig. 8).

No change in the magnesium content of the carbonate rock has been observed 1 the proximity of contiguous rocks or instrusions of amphibolite, granite, and egmatite.

Comparison with other carbonate rock deposits

The deposit of carbonate rocks at Stora Vika is at one end of a horseshoe rescent, running westwards from northern Uppland and southern Gästrikland, nd turning in Bergslagen proper towards the archipelagos of Södermanland and Östergötland (Fig. 1). There are a large number of carbonate rock deposits of arying size and shape along the rather wide horseshoe. The deposits, especially ne large ones, often form ridges covered with thin layers of soil, and may be everal kilometres long and up to 200 m or so wide. A common feature of these re-Cambrian carbonate rocks is that the originally horizontal strata have been fted into steep slopes and more or less folded. The carbonate rocks have been rgely subjected to the same degree of metamorphism. Limestone and dolomite one occur together in nearly all the deposits. Dolomite stone is the dominant ock in the two largest deposits of carbonate rocks in the bedrock, situated at Tora and Sala along the above-mentioned horseshoe, while limestone is present nly to a limited extent. Dolomite stone has been found in the immediate vicinity

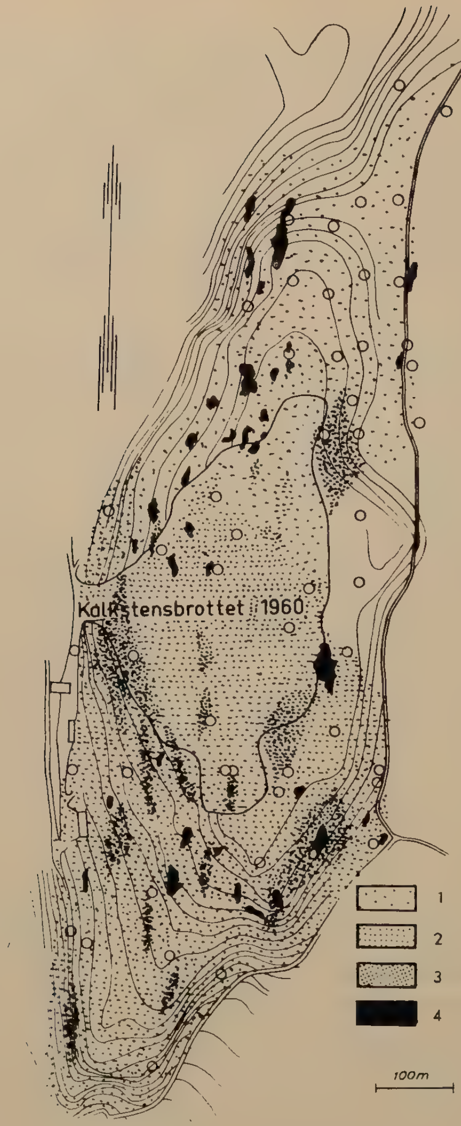

Fig. 19. Map showing the Ca/Mg ratio in the limestone hill at Stora Vika. 0 = diamond drill holes. 1. Limestone with < 2 % MgO. 2. Limestone with 2—3 % MgO. 3. Limestone with > 3 % MgO. 4. Gneiss, granite, and pegmatite.

of limestone in the large deposits of limestone within the region where limestone is extracted for lime-burning and cement-making, or has been investigated with a view to future extraction for such production.

In the description of limestone and the lime industry by Sundius (1942) there are survey maps of the limestone regions of Forsby and Lövsta, showing that limestone and dolomite stone occur together at both deposits.

The island of Oaxen, only five kilometres to the north-west of Stora Vika, consists of a slightly curved layer of limestone, two kilometres long. Drill cores from Oaxen show the following average analysis of the carbonate rock:

SiO_2	9.0 %	CaO	49.2 %
R_2O_3	1.6 %	Ignition losses	38.2 %
MgO	1.7 %		99.7 %
		Ca/Mg	34

According to the classification, the Oaxen carbonate rock is a magnesian imestone.

Compared with the limestone hill at Stora Vika, the limestone on Oaxen has a somewhat higher carbonate content and a lower magnesium content, originating mainly from diopside and phlogopite. No dolomite stone has been found, only occasional grains of dolomite in the limestone. It has not been determined what rock or rocks bound the limestone. Otherwise the deposits at Stora Vika and on Oaxen are of a very similar geological structure, with leptite banks and pegmatite inclusions, and dikes of amphibolite and diabase.

The deposit at Stora Vika is similar in many ways to, but different in certain respects from the great carbonate rock region at Sala, which the author (1953) nvestigated with reference to the calcite/dolomite ratio. The carbonate rock in he Sala region consists mainly of dolomite stone with boundary zones of limetone. In several places the author has found limestone in contact with dolomite tone, with sharp boundaries. No transitional forms with a successively increasing content of magnesium in the limestone are to be found. The dolomite stones at both Sala and Stora Vika contain calcite rather evenly distributed in the rock. The calcite usually occurs in two ways, in fissures and together with the silicate minerals, tremolite and forsterite (Fig. 20). The calcite in the fissures and cavties in the dolomite stone has undoubtedly crystallized from circulating soluions in connection with metamorphism or later. The calcite crystals in these places are usually much larger than the dolomite crystals. The other occurrence f calcite, in association with tremolite and forsterite, and to a certain extent lso with phlogopite, is very probably a reaction formation of siliceous dolomite tone during the metamorphic processes.

The dolomite-bearing skarn bands of green olivine minerals found in the limetone at Stora Vika are almost completely lacking at Sala.

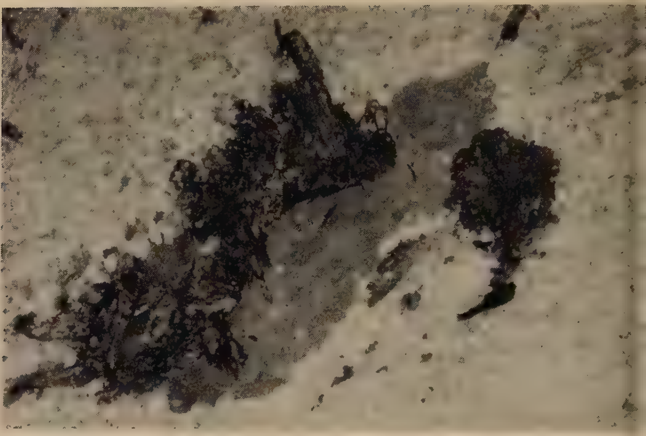

Fig. 20. Tremolite and calcite in dolomite stone from Sala. The mineral has been made more distinct by staining. 3 ×

Fig. 21. Serpentine and calcite (white streaks around the dark spots) in green marble from Kolmården. 1/5 ×

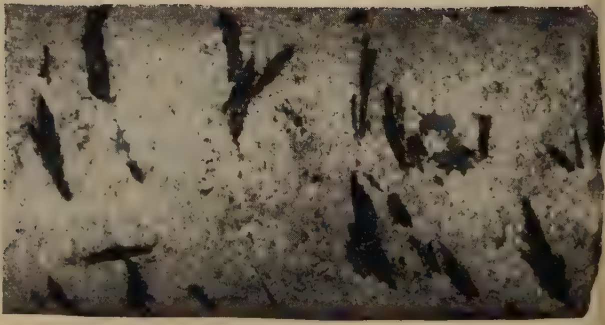

Fig. 22. Tremolite and calcite in dolomite stone from Ekeberg. The mineral has been made more distinct by staining. 1.5 ×

White and greenish marble is quarried at ten or so places in the leptite-hälleflint series. As the greenish marble is very reminiscent of the dolomite-bearing green skarn bands in the limestone at Stora Vika, the author has examined several samples from different marble quarries. The presence of calcite and dolomite has been demonstrated with the help of staining methods as mentioned above. Samples from Kolmården and Gropptorp, for example, show that the greenish marble contains chiefly the silicate minerals olivine and serpentine. Calcite and dolomite are present in almost equal quantities, but the calcite is localized mainly to the silicate-rich parts of the marble (Fig. 21). There also seems to be a concentration of calcite in the bodies of mica material that occur rather commonly n the rock. The white marble from Ekeberg can be characterized as a pure dolomite stone in which fissures and cavities filled with coarse-grained calcite crystals occur (Fig. 22). The silicate mineral present is mainly almost colourless tremolite, which usually occurs together with calcite.

The greenish marble may be regarded as siliceous dolomite stone, and as such t is in good agreement with the dolomite stone at Stora Vika, and also with the dolomite-bearing skarn bands in the limestone.

Discussion of the origin of dolomite in the leptite-hälleflint series of Central Sweden

It is generally accepted by Swedish geologists that the limestone in the leptite-hälleflint series of Central Sweden was formed by sedimentation in water. The original sedimentary features can still be discerned in the metamorphic limetones by the strata in the rock. Opinions differ regarding the origin of the dolomite stone. Many theories on the formation of dolomitic limestone and dolomite tone have been advanced and discussed in technical journals during recent years. The voluminous literature on this subject has been summarized time after ime (e.g. van Tuyl 1916, Linck 1937, Fairbridge 1957). The probable ways in which dolomite was formed in nature have been tabulated as follows:

Primarily in water:

a. Chemical precipitation from saturated solutions
b. Precipitation by the effect of organisms

Secondarily by metasomatism of limestone:

a. By the action of sea water
b. By magnesian solutions in the bedrock.

Fairbridge's collocation shows that direct precipitation of dolomite in sea water has not been proved. Only single dolomite crystals have been found in the bottom layers. Available thermochemical data suggest, however, that dolomite an be precipitated direct in sea water. Chilingar (1956) has managed to preipitate dolomite from sea water in laboratory tests at a CO_2-pressure of 4 atm.

Zen (1960), in studies of the equilibrium of carbonate in an open system, has demonstrated that carbonate precipitation in the open sea led to the formation of monocarbonate, either calcite or dolomite.

Dolomite has not been found in the surface layers in carbonate rock formations, laid down during modern times in the form of reefs in the open sea, although dolomite stone occurs lower down. The boundary between the two carbonate rocks is a sharp one.

According to Fairbridge's collocation, most of the dolomite stone formations are the result of metasomatic processes between limestone and magnesian solutions. A dolomitization of limestone may, according to the same authority, take place at different points of time, both before and after the diagenesis. What happens during dolomitizations is still unclear, but the reaction may begin with the absorption of magnesium in solid solution in the calcite crystal lattice (Goldsmith A. O., 1955). The problem is of great interest when prospecting for oil, for many oil fields are situated in porous, dolomitized limestone. Tinklepaugh (1959) has found a clear relationship between dolomitization and porosity in carbonate rocks in the oil-bearing Rogers City-Dundee formation.

As regards the Swedish occurrences of dolomite stones in the leptite-hälleflint series of Central Sweden, the author's investigations have shown that limestone and dolomite stone occur together in most places. The boundary between the two carbonate rocks is usually sharply defined. There are no successive transitional forms from limestone to dolomite stone, though the rocks may, in restricted areas, be embedded in each other. This agrees with Zen's (1960) theoretical calculations of the formation of monocarbonate. Calcite is present in large quantities in the Swedish dolomite stones, however. In the author's opinion, the formation of calcite in the dolomite stone is the product of metamorphic reactions between dolomite and silicic acid, whereby calcite is formed side by side with magnesian silicate (tremolite and forsterite). Similarly the formation of calcite crystals in cavities and fissures in dolomite stone is the result of a crystallization from circulating solutions. The author considers it highly probable that most of the dolomite stone deposits in Sweden have been formed either by direct precipitation in the sea, or by an early dolomitization of the limestone under the influence of the sea water. If dolomitization had taken place later, it is difficult to find a suitable source of the amount of magnesium required for the formation of dolomite, *e.g.* at Nora and Sala. As regards the content of magnesium in the actual limestone, it is probable that it, too, appeared at an early stages. Evidence of this is the fact that well-developed dolomite crystals have been found in the dense Cretaceous limestone at Limhamn, and also at Faxe (Forchhammer, 1850).

The dolomite-bearing skarn bands in the limestone at Stora Vika were, in the author's opinion, originally dolomite layers, rich in silicic acid, which, by metamorphic processes, have been largely transformed into forsterite and calcite

According to this assumption, no external supply of magnesium need be carried to the carbonate rock.

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Nils Zenzén 1883—1959

Några minnesord

Av

ERIK ÅHMAN

Min första närmare kontakt med dåvarande museiassistenten vid Riksmusei Mineralogiska Avdelning, Nils Zenzén, fick jag för bortåt 15 år sedan i samband med en beordrad genomgång på Sveriges Geologiska Undersökning av framlidne överdirektör Axel Gavelins efterlämnade bergartssamlingar. Etiketterna till ett omfattande stuffmaterial från Routivare i trakten av Kvikkjokk voro i viss utsträckning skrivna med stenografi enligt ett numera ej i bruk varande system. Detta vållade sålunda ett visst bryderi. Zenzén, som syntes hysa intresse för mitt arbete, hälsade på nära nog varje dag vid sina ronder genom Geologiska undersökningens lokaler. Han föreslog mig att för texternas tolkning inlära det aktuella stenografisystemet och anförde, att han hade stått inför liknande problem vid flera tillfällen. Tyvärr följde jag ej hans råd, som emellertid vittnade om att Zenzén själv ej skydde ansträngningar, då det gällde tolkandet och utforskandet av äldre texter.

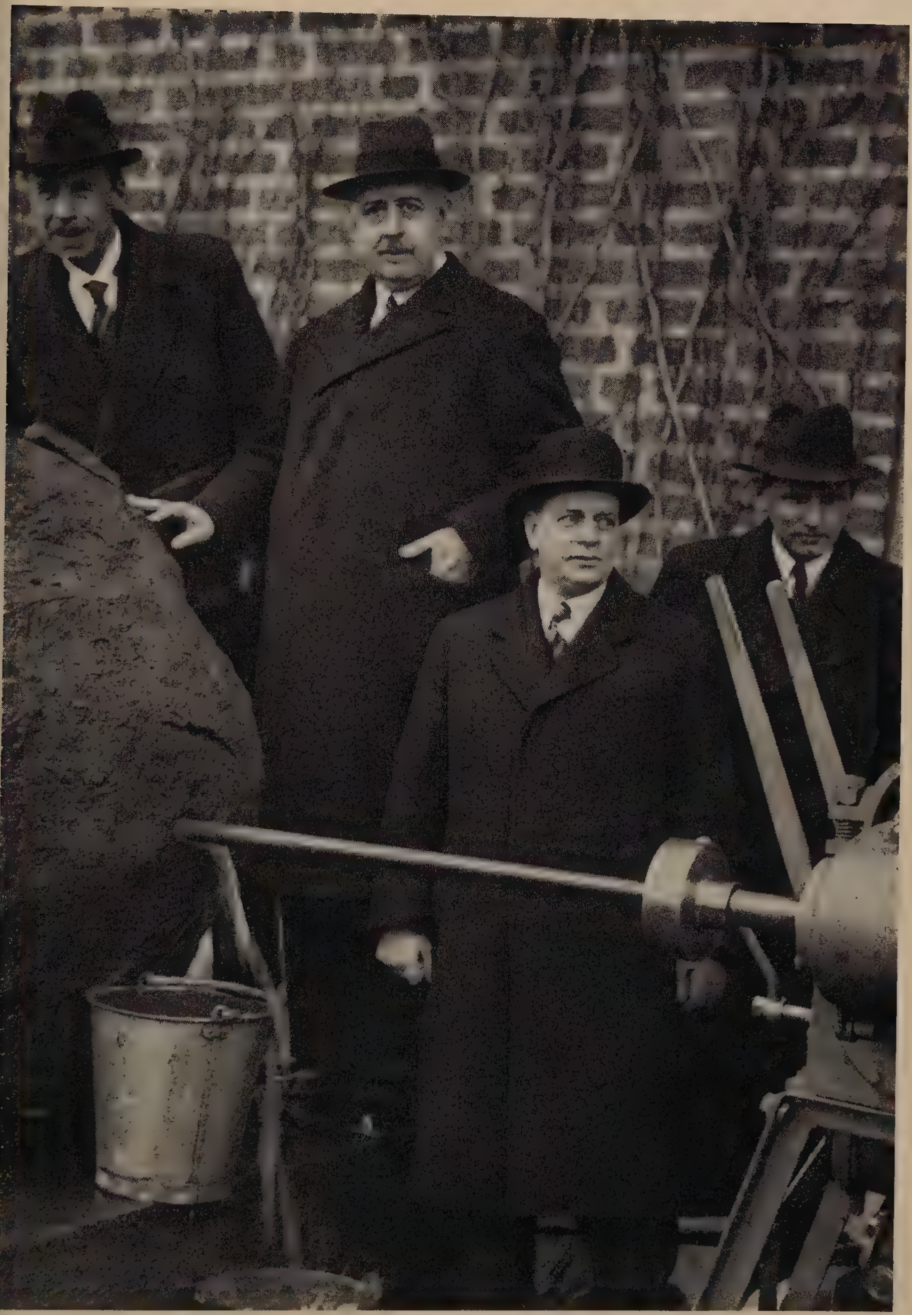
I samband med karteringsarbeten inom Sala gruvområde har jag sedermera blivit i tillfälle att taga del av hans efterlämnade anteckningar om Sala gruva och Salatraktens berggrund. Dessa utgör ett mycket omfattande material. Annotationerna behandla så vitt skilda saker som hällobservationer, uppgifter om ortsystemet inom delar av Sala Storgruva, data om kalkstens- och dolomitbrytning i äldre tid, uppgifter om Salamineral i utländsk litteratur samt ett flertal utkast till den berggrundskarta i skalan 1:20 000 över Salatrakten, vilken publicerats i Tegengren m. fl.: »Sveriges ädlare malmer och bergverk». Nämnda karta har också sedan 1920-talet varit den enda geologiska vägledning av betydelse för Salaområdet. Det snart hundraåriga geologiska kartbladet Sala är på grund av färgval och stark hällschematisering rätt svårtolkad beträffande just detta avsnitt. En redan hos Zenzén uttalad tanke på en berggrundskartering i betydligt större skala av detta Sveriges största urkarbonatstensområde har dock kommit att realiseras först i våra dagar.

Zenzéns liv och forskningsverksamhet utmärkte sig ej för ensidighet. Som ung student i Uppsala arbetade han på Kemiska institutionen med organiska synteser, bl. a. framställning av myricylalkohol ur carnaubavax. (Se J. A. Hedvalls uppsats »Från Nya Kemikums första tid» i festskriften tillägnad The Svedberg år 1944.) I början av 1900-talet deltog han även i den strapatsrika första detaljkarteringen av berggrunden inom Kiruna statsgruvefält och gjorde därvid insatser av bestående värde. Hans arbetsområde var förlagt till sedimenten inom norra delen av Kirunaområdet. Arbetsresultatet är dels inarbetat i Hj. Lundbohms guide till Geologkongressen år 1910, dels i den tillsammans med Nils Sundius år 1914 publicerade kartan över Kirunatrakten. Sedermera deltog Zenzén i utforskandet av fjällkedjans geologi, särskilt dess mellersta och södra delar. Till fjällen fattade han tidigt ett varmt intresse, vilket också framgår av hans produktion. I samband med dessa arbeten gjordes många intressanta upptäckter, vilka kommit senare forskning till godo.

År 1914 anställdes Zenzén som amanuens vid Riksmusei Mineralogiska Avdelning. Där kom han att, förutom åt uppställningen av den stora skådesamlingen, i stor utsträckning att ägna sig åt systematisk mineralogi. Vid denna tid vaknade även hans intresse för geologiens och mineralogiens tidigare historia i Sverige. I första hand inriktades detta intresse på ännu bevarade svenska mineralsamlingar från 1700-talet, och han studerade därför ingående och beskrev främst Bergskollegii stora samling i Stockholm. Även den Bielkeska mineralsamlingen tillhörig St. Kopparbergs Bergslags AB i Falun blev föremål för hans undersökning.

Sin stora erfarenhet på detta speciella område dokumenterade Zenzén påtagligt beträffande den Cederbaumska samlingen i Oskarshamn. Denna mineralsamling, som namngivits efter grundaren, bergsrådet Peter Christopher Cederbaum (1733—1795), hade länge stått övergiven och bortglömd i en vedbod tillhörig Oskarshamns läroverk. Genom ingripande från dåvarande rektor Hugo Grimlund i mitten av 1920-talet inkopplades Zenzén på dess räddande åt eftervärlden, en för honom mycket intressant uppgift. Samlingen, som på 1860-talet donerats till nämnda skola av ryttmästare Johan Fredrik Hultenheim på Fredriksbergs herrgård utanför Oskarshamn, genomgicks på ort och ställe och iståndsattes. Glädjande nog hade endast smärre delar av densamma gått förlorade. Samlingen uppordnades nu på det sätt den konstaterades ha varit i år 1781, nämligen efter J. G. Wallerius' »Systema Mineralogicum». Efter omfattande undersökningar lyckades det Zenzén att utröna icke blott vilka delar av samlingen, som en gång tillhört andra 1700-talssamlingar, utan även fastlägga, att samlingen under ett tidigare skede varit ordnad efter Wallerii äldre system av år 1747. Den Cederbaumska samlingen är i våra dagar i sina originalskåp och montrar deponerad å Riksmusei Mineralogiska Avdelning. Sedan denna deposition gjordes har emellertid Oskarshamns stad blivit ägare till och har iståndsatt Fredriksbergs herrgård, som nu bl. a. användes som kulturreservat, varför en återflyttning av samlingen dit skulle kunna tänkas. Resultatet från undersökningen publicerade Zenzén under den blygsamma titeln »Försök till historik över den Cederbaumska mineralsamlingen i Oskarshamn».

Rörande mineralsamlingar från äldre tider brukade Zenzén framhålla, att stuffetiketterna äro det viktigaste forskningsmaterialet. Stora skador ha åstadkommits av nitiska personer, som i samband med restaureringar och nyordningar av samlingar förstört äldre, ofta illa medfarna etiketter. Inför problemet



I samband med en av Sv. Diamantborrnings AB och AB El. Malmletning arrangerad utställning av borrmaskiner utanför SGU i mars 1938 gjordes en kärnborrning genom det stora blocket av Ovifakjärn utanför Riksmusei Mineralogiska Avd. I samband därmed togs ovanstående foto, vilket visar Nils Zenzén omgiven till vänster av professor H. G. Backlund samt till höger av direktör Karl Sundberg och nuv. direktör Sven Petersson.

att tolka texten på gamla stuffetiketter skydde han inga mödor. Genom sitt forskningsarbete var han också väl förtrogen med läsning av äldre skrivstilar.

Zénzén sysselsatte sig även med rent historisk forskning. Ett exempel på detta är hans arbete om den s. k. Stora Rubinen, en juvel, som svenska trupper tagit som krigsbyte i Prag år 1648. Den räknades som en av den kungliga skattkammarens dyrbarheter. När därför Gustaf III på sin inkognitoresa år 1777 till S:t Petersburg överhopades med skänker av den kejserliga familjen och den ryska vetenskapsakademien — bl. a. stycken av pallasitjärn i ett schatull av silver med hertigens av Gotland vapen på och numera tillhörande Min.-geol. institutionens i Uppsala meteoritsamling — lät han genom ilbud till hertig Karl föranstalta om omedelbart avsändande av ovannämnda dyrgrip som gengåva. Mineralogen professor Alexander Fersman, som 1925 för sovjetregeringens räkning mineralogiskt undersökte de ryska kronjuvelerna, kunde konstatera, att den ryktbara ädelstenen tyvärr endast är en rosafärgad turmalin. Fersman var personligen bekant med Zenzén och besökte denne vid ett tillfälle i Stockholm.

En utredning av liknande karaktär gjorde Zenzén beträffande det s. k. Swedenborgska marmorbordet hos Kungl. Kommerskollegium. Man påvisade att detta bord med mycket stor sannolikhet tillverkats i Holland och ej i Italien, som man dittills hade ansett.

För att återvända till Zenzéns arbeten inom Salaområdet så kan nämnas, att han påvisat, att i Storgruvans mineralparagenes ingår även albit och molybdenglans. — Bergsingenjör K. Johansson hade vid mitten av 1920-talet i en liten skärpning vid Gudmundstorp 3 km norr om Sala upptäckt ett nytt mineral, som efter fyndlokalen benämndes gudmundit och som har den kemiska sammansättningen FeSbS. Ett decennium senare spolierades lokalen genom ett husbygge, men Zenzén hann att i sista stund för Riksmusei räkning insamla ett stort material och konstatera, att gedigen antimon här även ingår i paragenesen. Mineralet gudmundit har sedermera påvisats i Skelleftefältets gruvor.

Belysande för Zenzéns mångsidighet är, att han även kom att ägna sig åt kvartärgeologi. I terrassen vid Moen i Årdal i Sogn studerade han vid ett tillfälle den av ler och mjäla uppbyggda varviga sedimentationen, som i början av detta århundrade uppmätts av J. Rekstad. Zenzén kom till den uppfattningen, att varvigheten på denna lokal ej representerar tydliga årsvarv och därför ej bör användas för fjärrkonektioner. Detta invecklade honom i början av 1930-talet i en polemik med professor Gerard De Geer.

Ett av Zenzéns viktigaste bidrag till svensk mineralogi och geologi är det stora antal biografier över svenska mineraloger och geologer, som han publicerat i skilda biografiska uppslagsverk och encyklopedier. För sina förtjänster om speciellt den svenska mineralogiens historia belönades han år 1954 med titeln fil. dr h.c. vid Uppsala universitet. Hans arbeten, som utmärkas av gedigenhet, äro grundade på synnerligen djuplodande och omdömesgilla studier. Professor P. Geijer anför om honom: »Ideligen, när man funderar över äldre uppgifter och över numera svårbegripliga beskrivningar om öde gruvor o.s.v., känner man hur mycken kunskap, som gick i graven med Nils Zenzén.»

Geologiska Föreningen i Stockholm omfattade Zenzén med stort intresse och han framträdde där som föredragshållare ett tiotal gånger. Dessa föredrag behandlade dock företrädesvis kvartärgeologiska och fjällgeologiska problem. Han var Föreningens ordförande år 1940 och ledamot av dess styrelse åren 1940—42.

Nils Zenzén var född i Skövde den 28 januari 1883 och avled i Djursholm den 4 juni 1959. Han avlade studentexamen i Karlstad 1901 och inskrevs samma år vid Uppsala universitet. Här avlade han fil. kand.examen 1906. Efter studier vid universitetet i Heidelberg blev han fil. lic. vid Stockholms Högskola 1914. Samma år fick han anställning som amanuens vid Riksmusei Mineralogiska Avdelning, där han 1926 utnämndes till museiassistent, vilken befattning han innehade till pensionsålderns inträde 1950. Fil. dr h.c. blev han som nämnt vid Uppsala universitet år 1954.

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Notiser

Remarks on the Ordovician ostracods described by A. Krause

By

VALDAR JAANUSSON

In the recent papers on the Ordovician ostracods of Balto-Scandia it has generally been assumed that the types of species described by Krause (1889, 1891, 1892) and formerly belonging to the Geologisch-Paläontologisches Museum of the Friedrich-Wilhelm-Universität, Berlin, have been lost during the last war. The material described by him comes from erratic boulders of northern Germany, and is obviously derived from the bed-rock of the bottom of the Baltic, Sweden, and Estonia. In attempts to identify his species the writers have had to rely only on his, *a priori* somewhat diagrammatic drawings and brief, often valueless descriptions. The identity of some of his species has been much debated.

The types of the taxa described by Krause, together with most of the other types belonging to the above museum, were returned to Berlin from Soviet Union in 1958, and are now deposited in the Palaeontological Museum of the Humboldt University (Diebel, 1960). On account of the impossibility to attain stability in the names of many Balto-Scandian Ordovician ostracods without a redescription of the types of species established by Krause, the present writer had to undertake a revision of at least part of this material. This was made possible by the loan of Krause's types of Ordovician ostracods to Uppsala, and the writer is very much indebted to Dr. Kurt Diebel for his generous help.

The examination of this material showed that Krause's figures were often less exact than supposed by previous writers, and that the real characters of some of his species are scarcely recognizable from the figures alone. Several of his species proved to be unsuspected senior subjective synonyms of well-known Balto-Scandian species. Although the revision of part of Krause's material is well advanced, it may take some time before new figures and descriptions will be issued. For this reason it seemed to be advisable to give a list of the species which, in the present writers opinion, are obvious junior synonyms to the species established by Krause. In proving the synonymy, types or topotype material was compared directly with Krause's type specimens. There may exist other species which later studies may prove to be identical with some of the species described by Krause, but in these cases the synonymy is not obvious, and further studies are needed in order to settle the problem. If not otherwise stated, the lectotypes are designated in this paper.

Primitia sulcata KRAUSE (Holotype KRAUSE, 1889, Pl. I, fig. 2) = *Conchoprimitia sulcata* (KRAUSE, 1889). Syn. *Primitia tolli* BONNEMA, 1909.

Primitia bursa KRAUSE (Lectotype KRAUSE, 1889, Pl. I, fig. 8; heteromorph) = *Euprimites bursa* (KRAUSE, 1889). Syn. *Euprimites bursellus* JAANUSSON, 1957.

Beyrichia digitata KRAUSE (Lectotype KRAUSE, 1889, Pl. II, fig. 12; tecnomorph) = *Glossomorphites digitata* (KRAUSE, 1889). Syn. *Glossopsis clavata* HESSLAND, 1949 and *Glossopsis lingua* HESSLAND, 1949.

Isochilina? erratica KRAUSE (Lectotype KRAUSE, 1891, Pl. XXIX, fig. 6) = *Conchoprimitia erratica* (KRAUSE, 1891). Syn. *Conchoides circumstriata* HESSLAND, 1949.

Beyrichia marchica var. *angustata* KRAUSE (Lectotype KRAUSE 1889, Pl. II, fig. 9) = *Tallinnella angustata* (KRAUSE, 1891). Syn. *Tallinnella dimorpha* ÖPIK, 1937.

Beyrichia erratica var. *acuta* KRAUSE (Lectotype KRAUSE 1891, Pl. XXXI, fig. 18, designated by HENNINGSMOEN, 1954, p. 53) = *Steusloffia acuta* (KRAUSE, 1891). Syn. *Steusloffia polynodulifera* HESSLAND, 1949.

Primitia labrosa KRAUSE (Lectotype KRAUSE, 1892, Pl. XXI, fig. 14; heteromorph) = *Uhakiella labrosa* (KRAUSE, 1892). Syn. *Uhakiella aequigranosa* JAANUSSON, 1957.

Entomis auricularis KRAUSE (Lectotype KRAUSE, 1892, Pl. XXII, fig. 5) = *Sigmobolbina? auricularis* (KRAUSE, 1892). Syn. *Sigmobolbina quanta* SARV, 1959.

Bollia major KRAUSE (Lectotype KRAUSE, 1892, Pl. XXI, fig. 18) = *Bolbina major* (KRAUSE, 1892). Syn. *Bolbina lehtmetsaensis* SARV, 1959.

Beyrichia (Tetradella) carinata KRAUSE (Lectotype KRAUSE, 1892, Pl. XXI, fig. 9; heteromorph) = *Carinobolbina carinata* (KRAUSE, 1892). Syn. *Carinobolbina estona magnifera* SARV, 1959.

Beyrichia (Ctenobolbina) rostrata KRAUSE (Lectotype KRAUSE, 1892, Pl. XXI, fig. 2; heteromorph) = *Sigmoopsis rostrata* (KRAUSE, 1892). Syn. *Sigmoopsis lamina* SARV, 1959.

Some of KRAUSE's species are based on so badly preserved or fragmentary specimens that it is difficult to see, how they ever can be recognized. For this reason the following species ought to be considered as nomina dubia.

Primitia cincta KRAUSE (Lectotype KRAUSE, 1889, Pl. I, fig. 4; heteromorph) = *Eobromidella* sp. indet.

Primitia intermedia KRAUSE (Lectotype KRAUSE, 1889, Pl. I, fig. 16; heteromorph) = *Euprimites* sp. indet.

Strepula lineata KRAUSE (Lectotype KRAUSE, 1889, Pl. II, fig. 3) = *Steusloffia* sp. indet.

Primitia (Ctenobolbina?) globifera KRAUSE (Lectotype KRAUSE, 1892, Pl. XXII, fig 9) = *Hesperidella* sp. indet.

Further studies may increase the number of nomina dubia among the species established by KRAUSE, the above being the obvious cases of species based on what according to the present writer's opionion are indeterminable specimens.

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Recensioner

Adrian E. Scheidegger: Principles of Geodynamics. 280 sidor med
86 figurer. Springer-Verlag, Berlin-Göttingen-Heidelberg 1958
Pris inbunden DM 49.60

Geodynamikens mål är att med hjälp av matematisk-fysikaliska teorier rekonstruera tillkomstsätten av de i jordskorpan genom dynamiska processer förorsakade förändringarna. Författaren framlägger i denna textbok-liknande sammanställning de mest kända geodynamiska teorierna, med huvudvikt på de fysikaliska respektive geofysikaliska förutsättningarna för de olika hypoteserna.

I de två första avsnitten ges en översikt över kända fysiografiska, geologiska och geofysiska data beträffande vår jord. Den inkluderar ämnen såsom geologisk evolution, kontinenternas och oceanernas geografi, orogenernas fysiografi, förkastningar och veckningar, gravimetriska och seismologiska data, jordens skalbyggnad, åldersbestämningar, termala data, magnetisering av bergarter samt geokemi. De följande avsnitten behandlar deformationsmekanismer, verkningar av jordens rotation, olika teorier över kontinenternas och oceanernas tillkomsthistoria, orogenes, förkastningarnas och veckningarnas dynamik, samt krafterna vid bildning av meteorkratrar, boudinage, domer, vulkaner och postglaciala höjningar.

Av denna uppräkning framgår att bokens innehåll behandlar ett mycket stort ämnesområde, där 280 sidor naturligtvis endast kan ge ett urval. Det ena eller andra kapitlet skulle man ha önskat sig något fylligare. Så kan t. ex. petrograferna tycka att avsnittet om bergartsdeformationerna är allt för översiktligt. Generellt skulle man välkomnat mer vägledande litteraturuppgifter för fortsatta studier. Äldre författares insatser, som inte enbart av pietetsskäl bör ha omnämnts, är ibland bortglömda.

De geodynamiska teorierna användas ofta för att bevisa riktigheten av en viss hypotes, vilket innebär att premissvalet blir mer eller mindre subjektivt. Författaren är väl medveten om detta och eftersträvar den objektiva framställning som ämnet medger. Om läsaren kommer ihåg detta och i de framlagda beräkningarna inte ser avgörande bevis för den ena eller andra hypotesen, så ger boken en stimulerande översikt för alla som är intresserade i geodynamik och strukturell geologi.

Hans J. Koark

Évolution des sciences. Masson et Cie. Paris. 12.
J. **Bourcart**: Problèmes de géologie sous-marine. 1958. 128 s. 1 pl.
20 fig. Pris 11 NF.

Ett par nummer i serien »Évolution des sciences» ha redan tidigare anmälts i denna tidskrift. Då föreliggande arbete tillhör ett forskningsområde, där svenskar i nutiden gjort mycket viktiga insatser — ej minst genom förbättring av de tekniska förutsättningarna för provtagningen — torde det vara motiverat att i korthet ge en antydan om bokens innehåll.

Arbetet är indelat i tre huvudavsnitt . De behandla *»le Précontinent»*, d.v.s. den under havsytan nedsänkta delen av kontinenten, vidare kusten och strandavlagringarna, samt slutligen den submarina stratigrafien, hur havsbottnarna registrerar förändringarna på jordklotet.

Begreppet *»précontinent»* är författarens eget och motsvarar shelfen (kontinentalhyllan) och kontinentalbranten. Bourcart redogör för olika åsikter om uppkomsten av detta bälte. Själv känner han havsbottnen och dess sediment särskilt från karteringsarbeten utanför franska medelhavskusten som bl. a. klarlagt utbredningen av de submarina dalarna. Dessa, som sträcka sig till mer än 2000 m:s djup, jämföras med världshavens s. k. submarina canyons. Faktorer, som kunnat påverka deras utformning diskuteras ingående, såsom t. ex. tidigare floderosion, förekomsten av submarina suspensionsströmmar *(»turbidity currents», »courants de turbidité)* och flexurer i kontinenternas randzoner, en hypotes som särskilt framhålles av författaren. Det bör erinras om att forskarna ännu äro oeniga om hur submarina canyons bildats, och att de troligen inte alla bildats på samma sätt.

I avsnittet om strandbildningarna diskuterar författaren olika typer av kuster, såsom cliff-kusten *(»la falaise»)* och de flacka tidvattenskusterna med estuariebildningar. Ett viktigt studieområde för tidvattenssedimentationen har varit Bretagnes norra kust, in mot Mont-Saint-Michel. Uppkomsten och utvecklingen av sandplager och deras skydd mot erosion ägnas betydande utrymme.

I det sista avsnittet diskuteras kortfattat havssedimentens tolkning i relation till klimatförhållandena under kvartärtiden och arbeten av svenskar citeras. Sedimentationen i Medelhavsområdet vid denna tid belyses med observationer från de franska intressezonerna m. m.

Tryckfel ha ej observerats, men i något fall ha icke-franska namn felstavats (Nörin, s. 62).

Arbetet innehåller fängslande diskussioner och borde i sitt hemland kunna stimulera intresset för havsbottnarnas geologiska gåtor även hos en vidare krets. I Sverige torde den lilla boken endast kunna intressera specialister. Förnämliga framställningar av hithörande problem finns som bekant lätt att tillgå på vårt eget språk (artiklar i Svensk Naturvetenskap!).

Britta Lundblad

ARNO SCHÜLLER: Die Eigenschaften der Minerale. I. Mineralbestimmung. 5. neubearb. Auflage. Akademie-Verlag, Berlin 1960. 200 s. Pris inb. 23:— DM.

När jag för mer än tre år sedan hade glädjen att anmäla fjärde upplagan av professor Schüllers välbekanta mineralbestämningstabeller, framförde jag en liten anmärkning mot sidhänvisningar i registret till de radioaktiva mineralen. Detta fel har nu blivit rättat.

Ett nytt och värdefullt inslag i den femte upplagan är en serie tavlor över de olika kristallsystemens yttre utbildningsformer. I övrigt är uppslagsverket sig likt och kan som tidigare med nöje rekommenderas till alla dem, som i sin verksamhet har behov av utförliga mineralexaminationstabeller. Priset är oförändrat från närmast föregående upplaga.

Per H. Lundegårdh

A. BENTZ: Lehrbuch der Angewandten Geologie. Erster Band: Allgemeine Methoden. Kartierung, Petrographie, Paläontologie, Geophysik, Bodenkunde. Ferdinand Enke Verlag, Stuttgart. 1961. XII + 1071 sid., 468 textfig., 3 pl., 75 tab. Pris hft DM 139:—, inb. 145:—.

Avsikten med denna omfångsrika volym är att ge en översikt över samtliga metoder, som kommer till användning vid geologiens praktiska utnyttjande. Boken utgör en modem efterföljare till Keilhacks »Lehrbuch der praktischen Geologie», vars andra och sista upplaga utkom 1921/22. Det föreliggande första bandet behandlar de grundläggande allmänna metoderna. Ett andra band, vilket planeras att snart utkomma, skall skildra mera speciella undersökningsmetoder beträffande malmer, salt, kol, olja m. m.

Arbetet är synnerligen omfattande; redan därav följer att en enda man icke förmår behärska hela detta väldiga kunskapsmaterial. Bentz står därför endast som utgivare — en i och för sig beundransvärd prestation. De enskilda kapitlen har, i varje fall i band 1, helt författats av en rad specialister — icke mindre än 30 stycken. Av redan nämnda skäl är det ej heller möjligt för en enskild recensent att bedöma alla de olika kapitlen. Här kan således endast mer allmänna synpunkter anföras.

Bokens första avsnitt behandlar vissa allmänna fältarbeten samt geologisk kartläggning. För detta avsnitt svarar Konrad Richter med smärre bidrag av andra författare. I kapitlet redogöres bl. a. för landskapets morfologiska drag och för det kartmässiga framställandet av dessa. Vidare behandlas geologisk kartläggning och en rad speciella undersökningsmetoder, bland vilka man finner blockundersökningar av olika slag, varvmätningsteknik, flygbildstolkning m. m. Det är som synes vitt skilda ämnen som ryms i detta enda kapitel. Detta gör, att trots bokens stora omfång många ämnen blir mycket summariskt behandlade. Detta gäller icke minst flygbildstolkningen, en metod som ju numera har mycket stor användning. Andra företeelser, t. ex. fältgeologens utrustning, karttecken m. m., kan i gengäld synas alltför utförligt behandlade, särskilt som i många fall de är av ganska begränsat intresse utanför Tysklands gränser. Av allmänt intresse är emellertid t. ex. en översikt över växter, som kännetecknar olika marktyper. Vidare är det av stort värde att få en samlad översikt av olika typer av borrar och annan fältutrustning, trots att man där finner huvudsakligen i Tyskland tillgängliga sådana, medan viktiga redskap från andra länder saknas.

I bokens andra huvudavsnitt skildras mineralogiska, petrografiska och geokemiska metoder. Goda översikter, av flera olika författare, ges här över provtagning och provberedning samt över såväl sådana metoder, som i vårt land tillämpas för de lösa jordarterna, som för rena bergartsstudier. Det gäller alltså slamnings- och siktningsförfaranden, mikroskopiska metoder, gefügeanalys, geokemiska metoder samt vidare omräkningsförfaranden enligt Niggli, »CIPW» och andra.

Avsnitt 3 redogör för paleontologiska metoder, såväl paleozoologi som paleobotanik. Härvid är preparationsteknik och vissa speciella förfaranden, såsom pollenanalys, av särskilt intresse. Man får t. ex. en god och koncentrerad översikt av de pollenanalytiska metoderna. Visserligen skall denna bok ej ge någon historisk översikt men då auktorer för de flesta förfaranden omsorgsfullt citeras, fäster man sig ändå vid att Lennart von Posts namn helt saknas.

Det mest omfattande huvudavsnittet är naturligt nog det som rör de geofysiska metoderna. Det har ej mindre än 24 upphovsmän och upptar 535 sidor. Här redogöres bl. a. för de även i vårt land använda huvudmetoderna, såsom tyngdkraftsmätningar, magnetiska och elektriska metoder samt seismiska förfaranden. I stort sett är dessa översikter grundliga och illustrerade med praktiska exempel.

Av intresse i samma avsnitt är vidare en översikt av de radioaktiva åldersbestämningsmetoderna, både C 14-metoden och de som används för mycket höga åldrar. Utom för åldersbestämningar används isotoper inom geologien för märkning av material vid studier av sediment- och vattentransport. Vidare är förhållandet mellan olika isotoper av vikt vid t. ex. bestämning av temperaturen under äldre skeden. Även för dessa metoder redogöres utförligt.

Till geofysiken räknas här även geotermiska undersökningar samt studier av porositet och permeabilitet, vilka jämte vissa andra undersökningsmetoder har sina speciella kapitel. Ett avsnitt ägnas även de problem som rör undersökningar i borrhål.

Bokens femte och sista huvudavsnitt ägnas markläran. Det har som upphovsman E. Mückenhausen och ger en utförlig översikt över de olika markprocesserna. Detta kapitel förefaller väl närmast att höra hemma i band 2 och illustrerar därigenom en viss oklarhet i dispositionen. Av stort värde i detta avsnitt är t. ex. en sammanfattning av Mellan-Europas markprofiltyper. Av mera begränsat intresse är t. ex. avsnitten om torvmarker och frostjord. I fråga om de förra anges endast huvudgrupperna försumpningsmossar (här = högmossar), igenväxningsmossar och övergångar dem emellan. Indelningen är föga tillämplig på våra förhållanden.

Frostjorden är kanske ett något perifert ämne men ändock förefaller litteratururvalet ej helt lyckat. Trolls stora översikt nämns visserligen men av tolkningsförsök av frostjorden nämns i övrigt endast Schenks minst sagt diskutabla hydratationsteori.

Några allmänna omdömen må till sist ges. Först skall framhållas att arbetet ej lämpar sig som kurslitteratur annat än på ett mycket högt stadium, ej heller för nöjesläsning. Redan den ansenliga vikten — över 2,5 kg — lägger hinder i vägen för den sistnämnda möjligheten. Däremot torde verket vara utmärkt som uppslagsbok — detta även i den bemärkelsen, att den som sysslar med ett eller annat problem här kan få goda uppslag till nya undersökningsmetoder och nya tillämpningar. Till denna användbarhet bidrar en tilltalande, modern typografi, goda illustrationer och ett lättfattligt språk. Detta är egenskaper, som man tidigare ej varit bortskämd med då det gäller tyska handböcker. Arbetet verkar i detta avseende influerat av modern amerikansk litteratur, vilket även ger sig tillkänna i kapitelnumreringen enligt decimalförfarandet.

Av stort värde är även de utförliga litteraturförteckningarna. En sådan hör till varje huvudavsnitt. Vidare förekommer kortfattade litteraturförteckningar även i underavdelningarna. Allt detta underlättar sökandet efter speciallitteratur.

Det säger sig självt, att då så många författare medverkar i ett arbete, de olika delarna därav måste bli av något skiftande karaktär. Man måste emellertid ge utgivaren en eloge för att han ej blott lyckats med den nästan övermänskliga uppgiften att avpressa 39 olika författare deras bidrag och samordna deras arbete, utan även åstadkommit en förvånansvärd enhetlighet.

Vissa anmärkningar kan självfallet göras då det gäller ett så stort arbete. Så t. ex. är det åtminstone beträffande somliga avsnitt alltför snävt inriktat på tyska förhållanden. Detta gäller framför allt karttecken och andra symboler. Beträffande vissa hjälpmedel har förhållandet redan ovan påpekats. Vidare förefaller en del detaljer nästan grönköpingsmässigt enkla: Att påpeka för paleontologen att han i fält bör medföra stövlar och regnrock syns ej helt nödvändigt och bryter något mot bokens i övrigt högkvalificerade kunskapsstoff. Men det är kanske bara ett utslag av tysk grundlighet att även upptaga dylika ting bland hjälpmedlen.

En annan anmärkning är att vissa översikter blivit alltför kortfattade i jämförelse med de övriga. Detta framhölls ovan beträffande flygbildstolkning och gäller även andra kapitel. Det är dock en helt naturlig följd av antalet medarbetare; och f. ö. skulle en grundlig behandling av alla dessa ämnen gjort boken ännu mer ohanterlig till omfånget. Bristen kompenseras i regel av hänvisningar till speciallitteraturen.

Som slutomdöme må framhållas att småanmärkningar av ovanstående slag ej får fördunkla det faktum, att vi här erhållit ett utomordentligt koncentrerat och dessutom välskrivet standardverk.

Jan Lundqvist

G. O. Raasch: Geology of the Arctic. I och II. University of Toronto Press. 1961. XV + 1196 sid., 437 fig., 95 tab. Pris $ 25.50.

Det föreliggande arbetet, i två volymer med tillhörande planschmapp, är i själva verket »Proceedings of the First International Symposium on Arctic Geology», vilket hölls i Calgary, Alberta, i januari 1960. Bidragsgivarna är följaktligen många — ej mindre än 125 stycken — och G. O. Raasch är »endast» utgivare. Avsikten med arbetet är att ge en allsidig översikt av Arktis och alla dess geologiska problem. Det säger sig självt att resultatet är ytterst heterogent och svårbedömbart. En kort översikt över innehållet må dock vara på sin plats för den som är intresserad av hithörande problem och ämnar utnyttja verket.

Band 1 innehåller regionala översikter och inleds med den sovjetiska delen av Arktis. I korta och överskådliga kapitel skildras områdets tektoniska utveckling, prekambrium, paleozoikum och meso—kenozoikum. Utförliga tabeller kompletterar beskrivningarna men tyvärr saknas i stor utsträckning kartor. Ett undantag utgör de båda yngsta erorna, vilka illustreras av en instruktiv liten kartserie. En tabell över parallelliseringen mellan de kvartära bildningarna i områdets olika delar med sådana i för oss mer kända delar av världen utgör även ett plus. Ett minus är att litteraturförteckningar lyser med sin frånvaro.

Följande avsnitt rör Spetsbergen. En omfattande redogörelse ges för den strukturella och geologiska utvecklingen. Goda tabellariska översikter, utmärkta kartor och en mycket utförlig litteraturförteckning bidrar till kapitalets värde. Till spetsbergsdelen hör vidare en liten men viktig uppsats av Weston Blake om dateringen av vissa strandnivåer. Detta har skett med C 14-metoden och genom korrelation med pimpstensnivåer, vilka daterats på andra håll i Skandinavien.

Till de mera utförligt behandlade områdena hör Grönland. En serie artiklar, författade av specialister, redogör för de olika strukturella och stratigrafiska enheterna. Dessa artiklar utgör en sammanfattning av resultaten av Lauge Kochs expeditioner, över vilka en översikt också lämnas. Utöver de redan nämnda behandlas även mer speciella företeelser, såsom faunan i vissa system, paleomagnetiska studier m. m. Till de flesta avsnitten hör goda tabeller och litteraturöversikter.

Utförligast behandlat är, naturligt nog, Canada. Medan dispositionen beträffande övriga regioner i stort sett är stratigrafisk, är tyngdpunkten i fråga om Canada i stället lagd på speciella problemställningar. Stratigrafiska och strukturella översikter ges visserligen även här men de flesta av de 17 artiklarna, av vilka några endast är abstracts, rör mer begränsade problem. Dessa är av de mest skiftande slag. Så t. ex. ges i flera av dem allsidiga översikter över smärre områden. Vidare exempel utgör beskrivningar av flygmagnetiska mätningar, foraminiferstratigrafi, evaporitstrukturer och gipstektonik.

Självfallet utgör artiklarna en heterogen samling, men i stort sett förefaller de goda och läsvärda. Illustreringen är likaledes i regel god och tabellariska översikter bidrar till överskådligheten.

Det minsta och desslikes minst givande avsnittet är det som rör Alaska. Bortsett från en uppsats om ostrakoder från den kvartära Gubik-formationen innehåller avsnittet endast några små sammanfattningar av uppsatser, som behandlar vissa äldre bergartsserier och tektonik.

Ett mer omfattande och utomordentligt intresseväckande avsnitt rör den arktiska oceanbassängen. Redan inledningskapitlet är, ehuru kortfattat, av stort intresse. Det ger en översikt över de olika teorierna om själva bassängens uppkomst. Inledningskapitlet för resonemangen in på speciella tektoniska problem, t. ex. beträffande Lomonosovryggen, den midatlantiska ryggens förlängning i Arktis, vilka avhandlas i följande kapitel. Detta är till en del faktorer som även har en vidare, principiell innebörd. Så t. ex. kan den seismiska störningszon som följer norr om den midatlantiska ryggen göra det sannolikt, att området mellan Eurasien och Lomonosovryggen vidgas. Därigenom ges ett visst stöd åt kontinentaldriftsteorien.

I de följande kapitlen redogöres bl. a. för undersökningar av grus från oceanbottnen. Detta är av klart glacialt ursprung och härrör troligen från området Axel Heiberg Island —Ellesmere Island—Nordgrönland. Vidare presenteras i en rad kapitel undersökningar av oceanbottnens morfologi och sediment. Det är bl. a. resultaten från de amerikanska arbetena på vissa isöar och från den finska Aranda-expeditionen till Barents hav 1957. Flera av uppsatserna är illustrerade med fotografier från havsbottnen. Djurlivet tycks ej vara alltför fattigt men den recenta sedimentationen är obetydlig.

Band 2 innehåller två sektioner. I den första finner man artiklar av mera principiell natur. De behandlar glaciologi, permafrost, klimatologi, geomorfologi m. m. Det skulle föra alltför långt att närmare presentera alla artiklarna, ehuru nog de flesta får sägas vara av stort intresse för svenska kvartärgeologer och geografer.

Studier av grönländska glaciärer visar t. ex., att dessa i norr är av rent arktisk typ, i söder däremot av den tempererade typen — vilket innebär att de i söder reagerar snabbare för klimatförändringar än i norr. På nordöstra Grönland drar sig f. n. glaciärerna tillbaka, men ändmoräner är tecken på framstötar i sen tid.

Vidare ges i sektionen ifråga en kortfattad men god översikt av periglacialfenomen i Canada — tyvärr ganska ofullständigt kända.

Av intresse är vidare en presentation av gravimeter- och seismiska djupmätningar av glaciärer på Ellesmere Island. God överensstämmelse mellan de båda metoderna har erhållits. Mätningar av glaciärtjocklek med andra metoder än de nämnda beskrivs från Alberta. Det är elektriska sådana, nämligen en konventionell motståndsmätning och en elektromagnetisk. Den sistnämnda har visat sig lämpligast för bestämningar av istjocklek och för studier av berggrunden under isen, medan motståndsmätningen är den bästa då det gäller studium av variationer inom ismassan.

Bland övriga artiklar om glacialgeologi och glaciologi må nämnas en principiellt viktig sådan om marin glacialsedimentation och en liten, men intressant detaljstudie av isön T-3 (Fletcher's Ice Island).[1]

Bland de klimatologiska artiklarna finns dels allmänna översikter, dels mera speciellt nriktade. I den förra gruppen saknas givetvis ej Ewing & Donn's teori — den tycks egelbundet dyka upp vid kongresser och symposier. Av specialartiklar av intresse må nämnas en undersökning av sambandet mellan klimat och permafrost i Canada. Permarosten ägnas f. ö. flera artiklar.

Utöver de nämnda huvudfrågorna finner man även andra problem behandlade i sekionen. Där finns t. ex. hydrologi och vidare är av stort intresse en metodisk undersökning av möjligheterna att datera bergytor med hjälp av deras lavvegetation. Denna meod är av stor vikt vid bestämningar av glaciärers avsmältning.

Verkets tredje och sista sektion behandlar en helt annan sida av Arktis, nämligen de roblem som rör organiserandet och genomförandet av expeditioner i dessa trakter, därmed sammanhängande försörjningsproblem o. dyl. Vidare ges översikter över de rent ekniska och praktiska möjligheterna för utförandet av vissa typer av vetenskapligt arbete nder arktiska förhållanden. Det gäller de mest skilda slag av arbeten, från geokemisk rospektering till förutsägelser av isförhållanden.

Ett allmänt omdöme om detta verk är ej lätt att avge, då ett arbete av dess typ naturgt nog måste uppvisa betydande variationer i fråga om kvalitet, utförande och intresse.

I stort sett gör dock verket ett mycket tilltalande intryck, typografiskt såväl som illustrationsmässigt. Skönhetsfläckar finns givetvis — annat vore otänkbart i sammanhanget. Emellertid är det helt säkert, att envar med intresse för de arktiska trakterna här har en betydande kunskapskälla. Även bortsett från detta specialintresse kan geologer och geografer med de mest skilda inriktningar i detta arbete finna artiklar av värde, artiklar vilka har principiell betydelse långt utanför de arktiska regionerna.

Jan Lundqvist

SHLIGIN, E. D. Short course in the geology of the Union of Soviet Socialist Republics. Translated title of —
Е. А. ШЛЫГИН: Краткий Курс Геологии С.С.С.Р. 1959, Moscow. Published by Госгеолтехиздат; 271 pp. Price 1.09 rubles.

The Soviet Union covers about one sixth of the land surface of the world, and it will hardly be denied that at least some information on its geological composition should be brought before the student of Historical Geology. The textbook by Strachov has been out of print for many years and the encyclopedic «геология с.с.с.р», appearing at present, is likely to be too comprehensive for most. The book here reviewed is an attempt to present a condensed synopsis of the geology of all parts of the Soviet Union, which seems to have been accomplished quite successfully. The volume is nothing like its American counterparts. There are no photographs, the entire illustrationary material being composed of maps and sections. There are no paleogeographic reconstructions.

The volume is divided into two parts. The smaller, first part is an introductory section which has chapters on the study of geological structures, the history of the development of geologic knowledge in the Soviet Union, a short discussion on the structure of the earth's crust, and finally the classification of the principal geologic regions of the Soviet Union.

The second part comprises most of the book and is concerned with accounts of the various geologic regions. The first chapter treats the geology of the Russian Platform (35 pp.). (It should perhaps here be inserted that "Historical Geology" as a university subject in the Soviet Union includes both the Precambrian as well as Cambrian onwards and thus differs from the procedure adopted in this country.) The treatment of the various systems is authoritative, even if greater detail in the paleontologic data would have been welcome. The section on the Russian Platform is rounded off by a discussion of the Ural-Emb depression, which is treated as a special subentity.

The next chapter deals with the Siberian Platform (20 pp.). It is followed by a chapter on the Paleozoic folded systems (90 pp.) which reviews particularly the Ural-Siberian Paleozoic belt including the development in the Salair-Saian, Altai, northeastern Kazachstan, Central Asian, Uralian, Novaia Zemlaian and Aral-Turgaian areas. The Mesozoic-Cenozoic folded systems are treated in the next chapter (30 pp.), beginning with the Pacific Ocean belt, which is succeeded by a section on the inner zone of this belt, including Eastern Asia.

The Soviet part of the "Mediterranean area" is discussed in 53 pages and includes the geology of the Don Basin, Mangishlak, the Crimea, the Black Sea, the Caucasus, the Turkmenian depression, Kopet Dag, the Balkans, the southern Caspian depression, and the Carpathians.

Throughout the book fossil names are frequently misspelled (e.g. *Ioldia* instead of *Yoldia* and *Didimograptus* instead of *Didymograptus*). All chapters contain a discussion of the Pleistocene geology of the area as well as a discussion of the mineral deposits and the tectonics.

The volume is rounded off with 5 pages of literature references, regionally arranged. The mode of presentation of the data is conventional and requires no special comment.

Several Soviet geologic textbooks have recently been issued in German translation. If the book here reviewed should appear as a translation, which is something to be hoped for, it would be desirable to have the number of illustrations, and their standard, increased.

R. A. Reyment

R. F. Hecker: Bases de la Paléoécologie. French language edition of Введение В Палеозкологию. Editions Technipues, Paris, 1960 (original version published in Moscow, 1957). 98 pp., 20 pls. Translated by J. Roger.

L. L. Sloss, E. C. Dapples, W. C. Krumbein: Lithofacies Maps. J. Wiley and Sons, Inc. New York, London, 1960. 108 pp.

The two publications reviewed here, the one a Soviet volume, the other an American represent, in certain respects, two ways of looking at the same topic, for which reason it would seem to the point to examine them side by side with regard to some aspects. The book by Professor Roman Hecker of the Laboratory of Paleoecology of the Academy of Science of the U. S. S. R. is a French translation of the "Introduction to Paleoecology", first published in 1957. The translation contains slightly more material than the original. Hecker's book has arisen primarily as a result of work in the Ordovician and Devonian of the Estonian-Leningradian area, the Carboniferous of the Russian Platform, and the Paleogene of the Fergana Basin, carried out by him over the last 30 years. In connexion with this work he devised a methodologic program of studying lithologic and paleontologic data simultaneously, the latter more or less semiquantitatively. The results are expressed diagrammatically in diagram pairs, the one showing lithofacies, the other the fossil components found in the various lithologic entities. At critical levels of time the environment is reconstructed both sedimentologically and biologically. Although other "paleoecologic" topics are taken up the main part of the publication is occupied by an account of Hecker's working procedure. For this reason the Russian title "*Introduction* to Paleoecology" is more appropriate than the French version's "Bases". The illustrations are generally satisfactory, although the plates showing museum displays are not particularly useful. The French translation is generally well done.

The second work is presented as an atlas of the United States and Canada and comprises 87 pages of maps printed in three colors. To a large extent it is the product of a course of instruction in regional stratigraphic analysis at Northwestern University and is largely based on information taken from published sources. The authors have been primarily concerned with areal variations in lithologic entities. Most maps are accompanied by a graphic device termed the "ratio triangle", which is used to indicate relative proportions between rocks of biochemical and chemical origin, rocks of coarse detrital origin, and rocks of fine detrital nature. The maps are also provided with isopach data.

For the non-American historical geologist the book is a treasure-house of invaluable graphic information on many American rock units from Cambrian up to Miocene and for this reason alone would have justified publication. The maps are also of great po-ential use as illustration material for lectures. It is obviously not an easy task to put ogether a volume composed almost entirely of maps of several sizes which must be re-ained in rigid chronologic order and in general it may be conceded that the publishers have succeeded well. Both books contain good ideas and handy information which, if employed in conjunction with each other, should provide a useful adjunct in the reconstruction of ancient environments.

R. A. Reyment

JAMES R. BEERBOWER: Search for the past. Prentice-Hall Inc., Englewood Cliffs, N. J., U. S. A. 1960, 562 pp.

It is indeed seldom that a book on Paleontology can give rise to unbounded enthusiasm on the part of a reviewer. The volume here under review is just such a rare bird. Textbooks on the market reflect to a lesser or greater degree the "stamp-collecting status" of a very considerable portion of contemporary Paleontology. Beerbower's book is a successful attempt to bring the student just starting out on his studies in this subject into contact with advanced trends in thought and a wide variety of problems, all simply presented. It is a book about Paleobiology and not just fossils.

In a chapter on shapes of animals such subjects as relative growth, form and function, and adaptation are treated. The species concept in Paleontology is discussed in terms of modern genetic theory with the aid of, for example, biometry, which makes the book one of the very few general paleontologic texts including statistical procedures as an integrated part of the presentation. A few minor details could be improved in connexion with the statistical formulae. That for the sample variance at the foot of page 65 is more acceptable in the form

$$s^2 = \frac{\sum (x - \bar{x})^2}{N - 1}$$

and that for the t-test for difference of means at the foot of page 66 is better as

$$t = \frac{(\bar{x}_1 - \bar{x}_2) \sqrt{\frac{N_1 N_2}{N_1 + N_2}}}{\sqrt{\frac{N_1 - 1) s^2{}_1 + (N_2 - 1) s^2{}_2}{N_1 + N_2 - 2}}}$$

A very useful section on the ecological and paleoecological characteristics of species is provided in which action/reaction systems, and classical Volterra/Lotka population dynamics are introduced in simple terms. Attention is paid to interaction with environment and between individuals and predator/prey/parasite systems are discussed in qualitative terms. The presentations are first illustrated neontologically and then carried over to a treatment of fossil situations. A following chapter, which treats of diversity in species, begins with a discussion of the significance of the transport factor in Paleontology. In the reviewer's opinion this is one of the few topics of the whole book that would benefit by further development. This chapter is, however, mainly concerned with zoogeography and animal associations.

Evolution is dealt with in two special chapters. The presentation is partly based on Kermack's *Micraster* work and such aspects as selection and mutation, isolation and genetic drift, evolutionary rates, and homeomorphy are taken up. A short chapter on stratigraphical paleontology is given.

The foregoing subjects are covered in the first 201 pages. The remainder of the volume is concerned with the systematic treatment of invertebrates and vertebrates in which anatomy and ecology are given pride of place. Each group is provided with a comprehensive glossary of descriptive terms. The coverage of the invertebrates meets well the requirements of the Swedish B-course in Paleontology. In almost all cases the treatment is good, even if the ostracods are dismissed in a few lines and three indifferent figures. Also the zoologic preamble to the cephalopod section could have been further expanded by, for example, taking notice of the work of Tinbergen and Verwey. Nor is the important topic of the nekroplanktonic dispersal of cephalopod shells taken up. It is, nevertheless, pleasing to observe that the author orientates cephalopod shells correctly in his figures. It is therefore surprising that despite this and other signs of careful attention to detail (such as correctly shortening millimeter as mm instead of the mm. of most English-language publications), a frequently-occurring spelling mistake has not been corrected. This is the spelling of *fasciole* as "fasiole" in figs. 6—4, 6—6, and 6—7. (The word is correctly spelled in the running text.) We note too with regret that on page 466 Professor Stensiö has been deprived of his Swedish nationality. On the whole, the author has done much better than the majority of his countrymen with respect to the "foreign literature", even if his coverage is far from representative.

Finally, a remark concerning the prose. Beerbower is obviously a skilful teacher. He writes in an easy, even racy, manner, borrowing much of his style and idiom from that of the journalist. This may prove irritating to some. The negative points brought forward in the foregoing are, however, of minor significance and in no way detract from the overall excellent impression made by the book. More productions of this kind are needed if Paleontology is to be moved from the rut of "second-rate sciences".

Search for the past can be heartily recommended as study literature for introductory courses in Paleontology.

R. A. Reyment

TALBOT H. WATERMAN (Editor): The physiology of the Crustacea. Academic Press New York / London. Vol. 1, 670 pp. (1960). $ 22.00; vol. II (681 pp., (1961). $ 22.00.

It might seem out of place to review a zoological publication in a geological journal. When we, however, call to mind that a large proportion of paleontological literature is concerned with crustaceans (ostracods) and near crustaceans (trilobitomorphs), with the biological properties of which the paleontologist is frequently poorly acquainted, it becomes apparent that a study of the kind here under consideration should be of vital importance in paleontologic research.

The work is presented in two volumes, the first being concerned with "metabolism and growth", the other with "sense organs, integration, and behavior". For the purposes of the present review only those aspects which are of direct interest in the study of fossil Crustacea are taken up. The topics presented in the books are mainly the results of recent research and to a lesser degree compilations from the literature.

Volume I comprises 17 chapters written by various authors. The first chapter treats general crustacean biology, which includes remarks on care of the eggs in crustacean groups (c.f. the brood pouch problem in the study of Paleozoic ostracods), and the anamorphic postembryonic development of ostracods. The external ramus of the trilobite limb is interpreted as an epipodite rather than a homolog of the crustacean exopodite, which would appear to necessitate a re-evaluation of the evolutionary meaning of the biramous nature of this appendage. Ostracoda and Conchostraca are thought to have a common origin.

In the chapter on *respiration,* important observations of paleoecologic importance are provided. For example, the ostracod *Cyprinotus incongruens* survives poorly in water saturated with pure oxygen; freshwater ostracods are particularly able to survive nearly anoxic conditions (which has been experimentally verified by the reviewer for *Cypridopsis vidua* and *C. obesa*). It is pointed out in this chapter that the gape of the carapace halves in ostracods directly influences the respiratory currents drawn in by the appendages.

The chapter on blood chemistry deals also with some aspects of molting and it is pointed out that each molting consists of a typical cycle — premolt — molt — postmolt; during the first of these stages resorption of the exoskeleton occurs and in the postmolt phase chitin, protein and inorganic salts are deposited in the new exoskeleton, both of these processes affecting the blood. Abundant chemical details accompany the points discussed in this section, which is clearly of great importance for the paleontologist who bases most of his deductions on the exoskeleton.

A chapter on *feeding* and *nutrition* contains information on the filtering mechanisms of ostracod mud-dwellers and such topics as the chitinous food rake and the filtering device of myodocope and platycope ostracods. It is also pointed out that the right and left valves of ostracods may work independently.

Of great importance in the study of fossil crustaceans is the occurrence of *parthenogenesis.* We learn, in a chapter on *sex determination,* that geographic parthenogenesis is characterized usually by the parthenogenetic form occurring further to the north and that, amongst ostracods for example, parthenogenesis is usually accompanied by polyploidy. Thus, in a sexual form a chromosome number of 16 is recorded, while the eggs of a parthenogenetic species were found to have 24 chromosomes. It is common for secondary sexual characters to develop late in the development of crustaceans (and this is born out by studies on fossil ostracods). The development of sexual variants in crustaceans is divided into stages of allometric growth, separated by critical periods, which suggests control by hormonal factors. This chapter also makes clear that *intersexuality* is something which the crustacean paleontologist should keep in mind in describing his material.

The chapter on *integument* and *exoskeleton* is particularly important to the paleontologist. Here, such vital factors as functional morphology of the skeleton (in *Conchoecia* the shape of the carapace is maintained by the pressure of the blood), apodemes and tendons, endophragmal skeleton, spines and setae, structure of the cuticle, and molting and growth are exhaustively discussed, Re the latter it is pointed out that research on decapods shows molting is followed by a growth phase in which the elastic new cuticle allows the size increase of the animal to take place, growth resulting from the intake of water. *Molting* is further treated in a special chapter in which such topics as the influence of various environmental factors are examined.

The important subject of *relative growth* in crustaceans is presented in detail in terms of allometry, variability, gradients and growth centers, relative growth and sexuality. In the latter connexion male polymorphism is reviewed.

In volume II, comprising 14 chapters, *mechanoreception* is treated in a special chapter in which the function of the crustacean seta is analyzed and also remarks on pore canals occur. Ostracods have chemoreceptors (aesthetascs), sexually dispersed, on the antennules and even on the antennae and they are able to discriminate among a wide variety of chemicals.

A particularly interesting section is that on *bioluminescence* in Crustacea, the ostracods being one of the most important bioluminescent groups. (Freshwater crustaceans are not bioluminescent.) A few other subjects treated are locomotion, physiological rhythms,

kinetic and tactic responses, and migrations. Important facts are presented concerning ontogenetic migration (for which there is evidence amongst certain species of fossil ostracods). In the final chapter on *comparative physiology* several important subjects are discussed amongst them being the rôle of the multivariate statistical technique of *generalized distance analysis* in crustacean taxonomy.

The overall editorial standard is good and overlap slight. The illustrations are mostly of high class and plentiful. Owing to the high cost of the volumes (about 260 Swedish crowns for both together) they are unfortunately out of the range of most private individuals. It is, however, hoped that all scientific institutions having anything at all to do with Crustacea will obtain this indispensible work.

R. A. Reyment

HILTERMANN, H. Unter Mitwirkung von ENGEL, G., Kaever, M., Sieverts-Doreck, H., 1961; Bibliographie stratigraphisch wichtiger mikropaläontologischer Publikationen von etwa 1830—1958 mit Kurzreferaten. E. Schweizerbart'sche Verlagsbuchhandlung. Stuttgart W. 1961. Broschiert 94:— DM, Einbanddecke 3.20 DM.

Eine grosse Sammlung von kurzen Referaten der gesamten Micropaleontologie liegt in dem neuen Werke Hiltermanns vor, das eine empfindliche Lücke unserer literarischen Hilfmittel schliesst. Das Werk erlaubt eine schnelle Übersicht von einschlägigen Arbeiten und dadurch wird dem Forscher viel unnötiges Aufschlagen bei Literaturstudien erspart. Hiltermann und seine Mitarbeiter haben sich das weite Ziel gesetzt, die gesamte stratigraphische Mikropaläontologie zu referieren und dies muss auf sehr grosse Schwierigkeiten stossen, falls eine Vollständigkeit erzielt werden soll. Im Vorwort wird aber schon eine wesentliche Einschränkung gemacht, nämlich dass eine Auswahl nach stratigraphisch *wertvollen* Gesichtspunkten gemacht wurde. Hier kann man einwenden, dass dies ein sehr subjektiver Standpunkt ist und damit werden de facto viele wichtige Arbeiten nicht berücksichtigt, so ist die botanische Literatur der Pollen und Sporen für das Quartär mager vertreten. Dasselbe gilt für die wichtigen Cuticula-Untersuchungen des Paleozoikums und Mesozoikums. Diese Einschränkung, dass z.B. die klassischen Arbeiten von Karpinski, Pander und Rohon fehlen, ist nicht berechtigt. Überhaupt entsteht die Frage beim Lesen, wo man heute die Mikropaläontologie abgrenzen kann. Histologische und morphologische Untersuchungen von Fischresten des Paleozoikum und Zähne und andere Knochenreste höherer Vertebraten des Mesozoikums gehören nach der Meinung des Referenten zur stratigraphisch wertvollen Mikropaleontologie und sind im vorliegendem Werke zu wenig beachtet.

Sieth man nun von solchen prinzipiellen Anmerkungen ab, so vermisst man doch in fast allen Kapiteln einige Arbeiten des referierten Gebietes, die wichtig sind. Die grosse Anzahl der gegebenen Referate (3210) macht das Werk, trotz meiner kleinen Kritik, wirklich zu dem Instrument, zu dem es angefertigt wurde. Dazu hilft neben der grossen Anzahl auch die knappe und doch sorgfältige Form der Referate. Gerade die kurzen Referate machen es dem Leser leicht einen schnellen Überblick zu bekommen. Ein weiteres wertvolles Hilfsmittel sind die Register (Autoren-, Sach- und Ortsregister). Wenn auch die Abteilung D.: Bibliographien, nicht vollständig ist und auch nicht vollständig sein kann, so ist auch dieses Kapitel von nutzen.

F. Brotzen

Mötet den 5 oktober 1961

Närvarande 47 personer.

Ordföranden, hr Hessland, öppnade sammanträdet, och yttrade därefter följande minnesord:

»Den 20 juli avled redaktionschefen fil. lic. Josef Carlsson, Lund, i en ålder av 61 år.

Carlsson var född i Pjätteryd i Småland och studerade vid Lunds universitet, där han blev fil. lic. 1930. Efter studier i USA och Kanada inträdde han samma år i redaktionen för Svensk Uppslagsbok, där han från år 1942 var en av huvudredaktörerna för första och andra upplagorna. Tillsammans med professor Sture Bohlin i Lund utgav han 1944 'Historisk atlas'. Som intresserad amatörgeolog deltog han livligt i arbetet inom Geologiska Fältklubben i Lund. — Vår Förening tillhörde han sedan år 1938.

Docenten Carl Caldenius avled den 10 augusti i en ålder av 74 år. Han var född i Stockholm och studerade vid Stockholms Högskola, där han disputerade 1924 på en känd avhandling med titeln 'Ragundasjöns stratigrafi och geokronologi'.

Följande år anställdes han som statsgeolog i Argentina och stannade på denna post i 5 år. Under denna tid företog han kvartärgeologiska forskningsresor till Patagonien under en period av 3 år. Efter sin anställning i Argentina gjorde han även forskningsfärder till Nya Zeeland och Australien (1933—1944).

Caldenius var verksam i Statens Järnvägars geotekniska kommission under åren 1914—1922, och efter sin återkomst från Argentina var han konsulterande geotekniker tills han utnämndes till statsgeolog 1944. Efter sin pensionering från statsgeologtjänsten 1955 bedrev han ånyo konsulteringsverksamhet och var styrelseordförande i AB Hagconsult.

Man kan urskilja ett par huvudlinjer i docenten Caldenius' verksamhet. Den ena, vilken omfattade 'geoteknik på det geologiska området' som han själv uttryckte det, leder tillbaka till hans verksamhet i SJ:s geotekniska kommission, där han bedrev en grundläggande forskning på det geotekniska området, som han sedan förde vidare. Det kan t. ex. erinras om att det kända Kullenbergslodet leder sitt ursprung till en konstruktion av Caldenius och Olsson. Hans saklighet och goda omdöme samt kritiska skärpa gjorde att han blev känd och uppskattad i vida kretsar både när det gällde rättsfall och praktiska utredningar av geoteknisk art, bland vilka många var av stor omfattning, t. ex. Slussombyggnaden i Stockholm och Götaälvsbron i Göteborg.

Kritisk skärpa utmärkte också hans insatser på hans andra huvudsakliga verksamhetsområde, som omfattade kvartär geokronologi grundad på lervarvsmätning. Hans viktiga lervarvsmätningar i Ragundaområdet var upptakten till en geokronologisk forskning, som kom att utsträckas till södra halvklotet och som omfattade inte bara lervarvsmätning utan även en noggrann kartering av glaciärerna. Dessa hans bipolara undersökningar blev ett starkt stöd för uppfattningen, att glaciationerna på de båda halvkloten var i stort samtidiga, men han var inte lagd för detaljerade fjärrkonnektioner. Caldenius intresserade sig också för permo-karbonska varviter. Hans geokronologiska arbeten är mycket kända internationellt, och hans namn hör till de mera bekanta bland de svenskar, som arbetat på södra halvklotet. En anledning till detta är den stora geografiska omfattningen av hans geokronologiska forskning, men därtill också att en del av hans arbeten är publicerade på spanska.

Under olika perioder verkade Caldenius som lärare vid Stockholms högskola, där han blev docent 1932. Efter sin pensionering från statsgeologtjänsten biträdde han som lärare i kvartär kronologi. Han var under hela sin verksamhet vid högskolan en stimulerande handledare, och han överlämnade generöst lovande forskningsuppgifter åt unga studenter att utvecklas vidare till licentiat- och doktorsavhandlingar.

Den 7 september avled civilingenjör Ejnar Lönnborg, Sandviken, i en ålder av 64 år.

Lönnborg, som var född i Gävle, studerade åren 1917—21 vid Tekniska Högskolan och utexaminerades därifrån som civilingenjör från avdelningen för elektroteknik sistnämnda år. Under 1920-talet var han anställd vid Haven and Artford Railroad i New York och under 1930-talet vid Cleveland Union Terminals Co i Ohio. Efter återkomsten från USA var han bosatt först i Stockholm och sedan i Sandviken. Han var en intresserad amatörgeolog och tillhörde vår Förening sedan 1941. Jag lyser frid över de bortgångnas minne.»

Professor Per Geijer uppvaktades med telegram på 75-årsdagen den 7 maj; sammaledes fil. dr Nils Sundius på 75-årsdagen den 21 maj och professor Percy Quensel på 80-årsdagen den 8 september. Tackskrivelser ha ingått.

Till ledamöter i Föreningen har styrelsen invalt fil. stud. Per Engqvist och fil. kand. Erik Norling, Uppsala, föreslagna av hrr R. Bergström och G. Eriksson, diplomingenjör László Gereben, Vällingby, föreslagen av hr O. Meier, ingenjör Ingemar Larsson, Hede, föreslagen av hrr A. Strömberg och Å. Hörnsten, samt ingenjör I. Ribenfors, Stockholm, och gruvingenjör G. Lindfors, Sala, föreslagna av hrr L. O. Martin och B. Collini.

Nederländernas geologiska undersökning samt Nederländernas geologisk-gruvtekniska förening komma att fira 60- resp. 50-årsjubileum den 26 april—3 maj 1962 med en gemensam kongress och åtföljande exkursioner. Närmare upplysningar lämnas av sekreteraren.

Det V. Nordiska geologiska vintermötet kommer att avhållas i Århus i Danmark den 8—10 januari 1962.

Cirkulär nr 1 rörande 1:a Europeiska Symposiet i »Zerkleinerung» i Frankfurt am Main den 10—13 april 1962 har kommit Föreningen till handa. Närmare upplysningar lämnas av sekreteraren.

Till Föreningens representant vid Geologiska Sällskapet i Finlands 75-årsjubileum den 27 oktober har styrelsen utsett hr ordf.

Hr O. Brotzen höll därefter ett med talrika ljusbilder illustrerat föredrag med titeln: Berggrunden inom östra delen av Bolidenfältet.

Inledningsvis hänvisades till tidigare geologiska arbeten inom Bolidenfältet. Särskild betydelse har E. Grips omfattande och ingående kartering. Av dennes karta framgår att fältet är en komplex antiklinal omgiven av skiffersynklinaler samt mot SV begränsad av Revsundsgranit, och mot Ö pekande mot Högdalskupolen. Föreliggande undersökning visar att östra delen av fältet är isoklinalt veckad. Längst i Ö är strukturen öppnare och tolkas som en synklinal (Djupgrovan), vilket stödes av observationer på graded bedding och en erosionskontakt. Här kan följande stratigrafi uppställas: I. Underlag av kvartsporfyr. II. Gränshorisonter med hastiga laterala variationer omfattande vittringsgrus, kalksten, porfyrkonglomerat — sericitskiffer, grått konglomerat, tuffit, arenit och svart, grå och grön skiffer. III. En grå, väsentligen vulkanisk, serie med en avdelning effusiva grönstenar överlagrad av kvartsporfyr — keratofyr. Intermediära led förekomma både över och under grönstenarna. IV. Övre, uthållig skiffer, som vilar på den övre kvartsporfyren eller dess klastiska derivat med tektoniskt störd kontakt. Dessutom förekomma i fältet porfyrgångar, ultrabasiter, granit av Jörntyp med tillhörande granitporfyrgångar, samt strängt N—S orienterade sprickpegmatiter. Graniten intruderar den undre delen av avdelning III.

Enheterna under IV ha lagts i isoklinala veck efter flacka axlar. Skiktbortfall och mylonitiska skiffer/porfyrzoner antyda att differentialrörelser mellan antiklinalerna ha ägt rum så att de östliga skjutits upp på de västliga. En skrynkling efter brant östliga axlar har givit upphov till regional stänglighet.

Den övre skiffern är tillsynes ej indragen i denna intensiva deformation, vilket tolkas som ett exempel på decollement, med avlösning i skifferns undre grafitrika delar. En normal diskordans är osannolik med tanke på den konkordans som härskar både i Högdalskupolen och i västra delen av Bolidenfältet. Även uppe i skiffern förekomma f. ö. både sura och basiska vulkaniter.

Yngre än dessa deformationer är Ö—V-liga förskiffringszoner av förkastningskaraktär (N-partierna ha sänkts) som genomdra fältet. De utgöra loci för sericitomvandling och malmbildning. Den mest betydande är Bolidenzonen som sannolikt är över en mil lång.

Ovanstående bild av en vulkanitserie, som med raskt växlande gränshorisonter vilar på en äldre kvartsporfyr och som uppåt följes av den övre skifferformationen aktualiserar en rad problem. Uppfattas gränshorisonterna som ekvivalenta med den kalkcementerade breccian vid basen av Vargforsformation innebär det att större delen av Bolidenfältet skulle höra till denna. Detta motsäges bl. a. av uppträdandet av »Jörngranit». Dess relationer kan istället motivera korrelation mellan fältets grönsten och Skoghedengrönstenen, som därvid hamnar ovan kalkstenen i vårt område. Själva malmbildningen synes strukturellt vara oberoende av och yngre än fältets allmänna veckning. Den markerade zoneringen av mineraliseringens karaktär i stråket Boliden, Långsele, Långdal anger en intensitetsgradient från N som skulle kunna antyda »karelidisk» ålder.

I anledning av föredraget yttrade sig hrr Gavelin, Hagerman och G. Kautsky.

Mötet den 2 november 1961

Närvarande 85 personer.

Ordföranden, hr Hessland, förklarade sammanträdet öppnat och meddelade följande:

Till ledamöter av Föreningen har styrelsen invalt fil. kand. Nils Erik Marinder, Kopparberg, föreslagen av hrr Ödman och Lindholm, fil. stud. Ulf Hallgren, Stockholm, och fil. stud. Bo Eriksson, Vaxholm, föreslagna av hrr Frietsch och G. Nilsson, ingenjör Stig Åsberg, Stockholm, föreslagen av hrr T. Eriksson och Åhman, ingenjör Sture Håkansson, Nora, föreslagen av hrr G. Kautsky och O. Brotzen samt bergsingenjör Bengt Holdar, Grängesberg, föreslagen av hr Ödman.

Vid Geologiska Sällskapet i Finlands 75-årsjubileum den 27 oktober representerades Föreningen av hr ordföranden, vilken vid högtidligheten i Helsingfors universitets festsal överlämnade en hyllningsadress.

Härefter vidtog en diskussion om »Geologerna och den praktiska utövningen» med inledningsanföranden av hrr C. G. Wenner, O. Meier och O. H. Ödman. Diskussionen presenterades av hr ordf. med följande ord:

»Mina damer och herrar.

Under senare år har man på skilda håll diskuterat frågor som berör å ena sidan utbildningen av geologer och å andra sidan förhållanden som ha att göra med deras yrkesutövning. Utbildningsfrågorna ha särskilt diskuterats i olika akademiska sammanhang. De senare frågorna har bl. a. varit föremål för en uppmärksammad diskussion i Geologiska sektionen av Naturvetenskapliga studentsällskapet i Uppsala. Geologiska föreningens styrelse anser alla dessa frågor så betydelsefulla, att föreningen som ju utgör en sammanslutning av alla landets geologer så aktivt som möjligt bör söka verka för geologernas sak. Till en början har man ansett att detta bör ske genom upplysning från initierat håll och diskussion. Vid detta sammanträde skall huvudvikten läggas på frågor som berör geologerna och den praktiska yrkesutövningen. På detta område försiggår en viktig utveckling som det är angeläget att få vederhäftigt belyst och därför ha vi inbjudit några initierade personer att medverka därtill med inledningsanföranden och diskussionsinlägg. I första hand kommer laborator Wenner att presentera en utredning som han utfört på uppdrag av Svenska Nationalkommittén för geologi.»

Sammanfattning av C. G. Wenners inledningsanförande

Som bakgrund till kvällens diskussion om geologerna och yrkesutbildningen vill jag ge några fakta om nuvarande förhållanden och göra försök till en prognos.

Hur många geologer finns det för närvarande? — År 1960 fanns det 186 svenska yrkesgeologer, pensionärer inräknade, emedan dessa vanligen äro verksamma som geologer på ett eller annat sätt. En stor del av geologkåren består av lågt avlönade, yngre geologer. Av de 186 geologerna äro de flesta i huvudsak sysselsatta på visst ämneseller verksamhetsområde enligt följande tabell, som också visar en uppdelning på »praktiska» yrkesgeologer och geologer i huvudsak sysselsatta med forskning eller undervisning vid universitet, högskolor och riksmuséet.

Ämnes- eller verksamhetsområde		Tillämpad geologi	Forskning och undervisning	S:a
I	Mineralogi, petrologi, malmgeologi	54	27	81
II	Historisk geologi, paleontologi, oljegeologi m. m.	4	23	27
III	Kvartärgeologi, jordartslära, tillämpad kvartärgeologi	28	21	49
IV	Ej specialiserade	28	1	29
	Summa	114	72	186

I en uppsats i Geologiska Föreningens Förhandlingar, »Den akademiska utbildningen av geologer, speciellt vid Stockholms Högskola», tryckt år 1952, redovisar jag en liknande sammanställning. En jämförelse mellan de båda utredningarna visar, att statliga verk och privata företag med behov av tillämpad geologi fått större antal yrkesgeologer av kategori I, III och IV. Sveriges Geologiska Undersökning med 32 tjänster år 1960 dominerar ej längre så mycket som arbetsgivare för »praktiska» geologer. Privata företag ha redovisat 45 befattningar samt statliga företag utanför S. G. U. 23 befattningar.

Hur stort är behovet av geologer? — På grund av ålderspensionering bli 10 befattningar lediga per 5-årsperiod under närmaste decennium, dvs *i medeltal 2 befattningar lediga per år*. På grund av sjukdom, dödsfall eller övergång till annan verksamhet före pensionsåldern kan antalet lediga befattningar beräknas öka från 2 till 2 à 3. I verkligheten blir behovet säkert större på grund av att nya befattningar inrättas. En prognos för detta behov är givetvis svår att göra. Enligt en utredning utförd av mig skulle det under närmaste decennium kunna behövas ca 30 nya geologbefattningar i den privata sektorn, ca 20 i den statliga och ca 15 för forskning och undervisning. Sammanlagt blir detta 65 nya tjänster eller *i medeltal ca 6,5 nya befattningar per år*. Under närmaste decennium skulle det totala behovet på nuvarande och prognoserade befattningar kunna bli 20 + 65 = 85 stycken, dvs *sammanlagt knappt ca 9 geologbefattningar lediga per år*, motsvarande 3 från varje universitetsstad.

Motsvaras presumtiv efterfrågan av kvantitativ tillgång vid universiteten? — Blivande yrkesgeologer välja i allmänhet högsta betyget i fil. kand.-examen och taga förr eller senare en fil. lic.-examen. Högsta betyget i fil. kand.-examen har under decenniet 1949—58 tagits av 54 studerande i hela riket, dvs *i medeltal drygt 5 studerande per år* Antalet fil. lic.-examina har under samma decennium i hela riket varit 49 stycken, dvs *i medeltal nära 5 filosofie licentiater per år*. Tillgången på utbildade geologer från universiteten, 5 à 10 per år, är sålunda större än nuvarande efterfrågan 2 à 3 per år, men å andra sidan kommer efterfrågan sannolikt att öka med åtminstone några nya befattningar per år. Det synes icke för närvarande föreligga någon stor discrepans mellan tillgång och presumtiv efterfrågan på yrkesgeologer.

Ett stycke in på 1950-talet inträdde en markant ökning av antalet geologistuderande. Enligt statistiken vid Stockholms universitet nöja sig de flesta med betyget Godkänd i mineralogi- eller geologiämnet, dvs de använda betygen som stödämnen för annan yrkesutbildning än geologens. Antalet tentander för högre betyg har ej ökat under 1950-talet. Antalet 3-betygstentander har vid Stockholms universitet varit i medeltal 2 à 3 per år. Stockholms universitet producerar sålunda ensamt hela rikets nuvarande behov av yrkesgeologer och redan sin tredjedel i ett presumtivt behov.

Är den praktiska yrkesutbildningen kvalitativt tillfredsställande? — På olika delfrågor belysande denna frågeställning ha i en enquete till verk och näringsliv framkommit önskemål om dels vidgad undervisning i geologiämnena, dels vidgad kunskap i vissa stödämnen. Om jag skulle våga mig på en sammanfattning av önskemålen i det omfångsrika materialet, kan följande anföras:

1) beträffande berggrunden ökad kunskap i tektonik och malmgeologi inkl. geofysik och prospektering, 2) beträffande jordarter ökad kunskap i kvartärgeologi och geotekniska spörsmål och 3) beträffande geologi i gemen ökad tillämpning till verkligheten, i vissa fall anknytning till tekniska specialämnen och ökad kunskap i stödämnen, främst fysik och matematik.

Vad önskemålet om vidgad undervisning beträffar, är detta i hög grad tillgodosett i de förslag till nya organisationsplaner för den geologiska ämnesgruppen, som nu föreligga och som redan i slutet av vårterminen 1961 voro föremål för en kanslerskonferens. Beträffande önskemålet om vidgad kunskap i vissa stödämnen är det de studerande själva, som »ha bollen». Det har tyvärr alltid varit få geologistuderande, som haft matematiska ämnen i examen. Av detta fåtal har blott en liten del blivit yrkesgeologer. Det allvarligaste synes vara, att den lilla procenten geologistuderande med ämnena matematik, fysik och mekanik ej har ökat utan snarare tvärtom. Geologer med nämnda ämnen i examen komma att ha större konkurrenskraft både bland geologer och andra yrkesgrupper i framtiden.

Slutord vid diskussionen, av Wenner

Kvällens diskussion har i första hand kommit att beröra utlandsmarknaden för svenska yrkesgeologer. Geografiskt sett äro presumtiva arbetsområden begränsade. I Europa torde arbetsmöjligheterna ej vara många. Folkrepublikerna ha icke behov av svenska yrkesgeologer. I USA har det funnits viss arbetslöshet bland geologer. I Sydamerika ha åtminstone ABC-staterna egna utbildningsanstalter. Australien har fortfarande geologutbyte med det gamla moderlandet. Återstår som arbetsområden delar av Sydamerika, Afrika, Orienten och Indien. Det gäller sålunda tropiska och subtropiska områden mycket annorlunda vårt lands geologi, t. ex. tertiära veckbergsområden med yngre formationer väl kända av schweizare, vittringsjordarter studerade i USA och grundvattenfrågor i torrområden, där bl. a. fransmän utfört pionjärarbeten och ha stor erfarenhet.

Det behövs högt kvalificerade specialister, som äro verksamma bl. a. i FN:s regi men vanligen blott kortare tid, innan de återvända hem. Utvecklingsländerna ta helst emot större företag, som projektera, bygga och bidraga med finansiering, såsom Lamcos verksamhet i Liberia. I denna typ av verksamhet dominera stormakterna.

Om svenska geologer under närmaste decennium skulle kunna placeras i stort antal utomlands, t. ex. 20 i Sydamerika, 20 i Afrika och 20 i övriga områden, innebär detta i medeltal ett behov av 6 geologer per år och 2 per universitetsstad. Så många lär det väl aldrig kunna bli, men ökade möjligheter på utlandsmarknaden torde finnas för svenska geologer och andra yrkesgrupper, särskilt om svenska staten, organisationer eller företag intressera sig för bilaterala överenskommelser mellan vårt land och enskilda utvecklingsländer.

Referat av O. Meiers inledningsanförande

Inom näringslivet ställes olika fordringar på en praktisk geolog allt efter de skiftande uppgifter som geologen sättes att lösa. Bland generella fordringar kommer först och främst en brett upplagd grundutbildning, där utom de vanliga ämnena speciell vikt bör läggas vid tektonik och regional utomskandinavisk geologi. Andra allmänna krav är goda språkkunskaper, förmåga att muntligen och skriftligen uttrycka sig sakligt och koncist, omfattande litteraturkännedom, organisationsförmåga, samarbetsvilja, intresse och sinne för ekonomiska frågor samt anpassningsförmåga för att kunna arbeta i främmande miljöer och under skiftande yttre omständigheter. Den praktiske geologen bör även vara fysiskt härdad och i psykisk jämvikt.

Den praktiske geologen måste räkna med att under sin yrkesutövning få uppdrag, där hans omdöme, ansvarskänsla och förmåga att överblicka ekonomiska sammanhang ställes på hårda prov. Stora värden kan vara på spel vid tillfällen då geologens utlåtande är avgörande, t. ex. när det är frågan om uppskattning av en mineralfyndighets storlek och brytvärdhet eller om bedömning av grundförhållanden resp. bergets beskaffenhet vid projektering av byggnadsverk, dammar, bergrum, tunnlar, etc.

Fackutbildningen bör för alla geologer som söker sig in på den praktiska banan utöver grundutbildningen omfatta åtminstone allmän orientering om fotogeologi, geofysiska och geokemiska prospekteringsmetoder, hydrogeologi, geoteknik och borrteknik.

Särskilt framhölls den betydelse som hydrogeologin har fått i stora delar av världen, speciellt inom arida områden och i utvecklingsländerna, varför utbildningen av svenska hydrogeologer bör forceras. I de flesta andra kulturländer finns redan ett relativt stort antal hydrogeologer, som sändes till utvecklingsländer, antingen genom förmedling av FN eller genom direkt engagemang av respektive länders regeringar.

Sverige, som ett land stående utanför stormaksblocken, bör ha vissa utsikter att kunna placera välutbildade praktiska geologer, speciellt i utvecklingsländerna. Även i Sverige finns det potentiella möjligheter till ökade arbetstillfällen för praktiska geologer.

För geologer med otillräcklig utbildning och bristande erfarenhet är utsikterna för anställning som praktiska geologer dåliga. Det är nödvändigt att de unga svenska geologer som vill ägna sig åt praktiska uppgifter bereds tillfälle till specialutbildning och praktik ej endast i Sverige utan även i utlandet.

Inledningsanförande vid Geologiska Föreningens sammanträde den 2 november 1961

Av Olof H. Ödman

Tema: Svenska geologers arbetsmöjligheter i främmande länder.

I utländsk gruvteknisk fackpress, särskilt engelskspråkig sådan, ser man ofta annonser i vilka statliga institutioner och privata företag söker geologer för praktiskt geologiska uppdrag. Två års erfarenhet samt åtminstone en lägre akademisk examen fordras. Inom sterlingblocket är begynnelselönen £ 120 och i dollarområdet $ 400 per månad. Därtill kommer olika tillägg såsom hyresbidrag, traktamenten m. m. Det är mig icke bekant huruvida idag några svenska geologer finns anställda i utländska institutioner eller bolag. Tidigare var detta fallet i t. ex. Argentina, Tanganyika, Norra Rhodesia, Syd-Afrika, Etiopien och Canada.

I FN:s biståndsverksamhet i utvecklingsländerna ingår även uppdrag av geologisk och gruvteknisk karaktär. Experterna för dessa uppdrag rekryteras i Sverige genom Svenska Institutets avdelning för Tekniskt Bistånd på Fleminggatan i Stockholm (sker fr. o. m. 1 januari 1962 genom Nämnden för internationellt bistånd, NiB). I första hand rör det sig om högt kvalificerade personer med 8—10 års erfarenhet och helst med högre examen. Anställningstiden kan vara mindre än 1 år men är i regel 1—2 år, stundom längre tid. Lönen är $ 730 eller mer per månad, vartill kommer särskilda tillägg efter speciella villkor. Att märka är att lönen är befriad från skatt såväl i Sverige som i uppdragslandet.

Svenska Institutet har publicerat en folder med detaljer betr. expertuppdragen samt sänder varje månad ut en förteckning över aktuella expertuppdrag.

Expertuppdragen berör de mest skilda grenar inom geologin, som t. ex. saltgeologi i Chile, hydrogeologi i Volta, Niger och Mali, »mining and geology adviser» i Centralamerika, geologisk kartering i Förenade Arabrepubliken samt stratigrafi och malmgeologi i Grekland. F. n. arbetar följande svenska geologer på FN-uppdrag: Dr Elis Dahlström i Chile, Doc. Pontus Ljunggren i Bolivia, Dr Nils H. Brundin i Egypten, Doc. Otto Brotzen på Filippinerna och Statsgeolog H. Tullström på Barbados. Tidigare har svenska geologer arbetat för FN i Turkiet, Jordanien, Argentina, Uruguay, Centralamerika och Brasilien.

Vissa länder sänder även ut s. k. »junior experts» som assistenter till experterna. I Sverige Hjälper-utredningen föreslogs 1959 att svenska experter inom FN:s tekniska bistånd skulle kunna biträdas av dylika »junior experts». Experten skulle därigenom kunna arbeta mer effektivt och hans arbetstid utnyttjas mer rationellt. I vissa fall kunde tänkas att experten arbetade på fältet endast under kortare perioder och i stor utsträckning överlämnade åt biträdet att fullfölja arbetet och upprätthålla kontinuiteten i detta. Det har framhållits, att ett arrangemang med biträdande experter skulle öppna en väg för yngre personer till aktivt deltagande i biståndsarbetet. Ett dylikt junioruppdrag skulle ju dessutom innebära värdefulla erfarenheter.

Frågan om juniorexperter är under utredning och jag kan för dagen icke lämna några ytterligare uppgifter.

Även flera svenska privata företag har geologiska utlandsintressen. Det är här icke bara fråga om företag med malmletning och malmgeologi på programmet utan det gäller också i stor utsträckning företag, som utför borrningsarbeten, vattenbyggnadsanläggningar, hydrogeologiska undersökningar m. m.

Enligt min personliga övertygelse bör geologen resa ut och skaffa sig praktik redan i unga år. Han kan gärna resa redan före kandidatexamen men bör då ej stanna ute längre än 1 à 2 år.

De geologiska arbetsuppgifter som jag här åsyftar är av tillämpat geologisk natur. Det är emellertid ej bara malmletning och malmgeologi eller allmän geologisk undersökning, utan minst lika ofta rör det sig om geoteknik och hydrogeologi, stratigrafi, olja eller salt.

Som tidigare har påpekats här i kväll, ställer dessa uppgifter stora krav på geologen i fråga om hans kunskaper i tillämpad geologi, kunskaper som han idag endast i liten utsträckning kan förvärva genom akademiska studier vid våra universitet. Vad vi i dessa avseenden saknar är den engelska och amerikanska geologiska utbildningen, som leder till en examen som »mining geologist».

Bortsett från kunskaper i tillämpad geologi är det givetvis också önskvärt att geologen har en fast bas vad rör grundvetenskaperna — matematik, mekanik, kemi.

Som också tidigare framhållits i kväll måste på de tillämpat geologiska arbetsuppgifterna även ekonomiska synpunkter läggas. Det är många gånger här fråga om investeringar av mycket stora summor och geologens omdöme om projektet är av utslagsgivande betydelse.

Jag vill sluta mitt anförande genom att citera Svenska Dagbladets intervju med professor Percy Quensel på hans 80-årsdag, där han säger: »Världsomspännande måste geologens liv bli, hans yrke är internationellt i högsta grad».

Mötet den 7 december 1961

Närvarande 61 personer.

Ordföranden, hr Hessland, förklarade sammanträdet öppnat, varefter sekreteraren meddelade följande.

Till ledamöter i Föreningen har styrelsen invalt amanuens Göran Bylund och fil. stud. Bo Lundberg, båda från Lund och föreslagna av hr Hjelmqvist, ambassadrådet professor Marcel Gigout, Stockholm, föreslagen av hr Asklund, samt docent Rolf Köster, Kiel, föreslagen av hr Åhman.

Nästa sammanträde har utsatts att äga rum först den 18 januari 1962.

Därefter skedde val av styrelse för år 1962, varvid utsågos:

till ordförande hr E. Fromm,

till sekreterare hr E. Åhman,

till redaktör för Förhandlingarna hr P. H. Lundegårdh,

till skattmästare hr Gabrielsson,

till övriga ledamöter av styrelsen hrr I. Hessland och T. Eriksson. Till revisorer att granska 1961 års förvaltning utsågos hrr J. De Geer och G. Stålhös med hr H. Möller som suppleant.

Hr Asklund framförde ett inom styrelsen väckt förslag om instiftandet av en Gerard De Geer-medalj och en Alfred Elis Törnebohm-medalj samt bildandet av en medaljfond. Ärendet bordlades till nästa sammanträde.

Herr Asklund yttrade: Vid ett styrelsesammanträde under våren erinrade vi oss att jämnt 90 år förflutit sedan Geologiska Föreningen bildades. I anledning därav uppkom en diskussion huru vi skulle tänka oss firandet av det år 1971 infallande 100-årsjubiléet och om det redan nu vore anledning tänka på huru minnet skulle på något särskilt sätt celebreras. Sannolikt var det jag själv, som väckte frågan att Föreningen skulle instifta en eller två medaljer att hugfästa minnet av dess mest prominenta ledamöter under Föreningens 100-åriga tillvaro. Kamraterna i styrelsen upptogo detta förslag mycket gynnsamt, i synnerhet sedan jag nämnt de bägge namn, som stodo för mig, nämligen Alfred Elis Törnebohms och Gerard Jakob De Geers. Det säger sig självt att en prominent forskare, in- eller utlänning, inom något av den nordiska geologiens tvenne stora arbetsfält, den prekvartära respektive kvartära geologien, skulle känna sig utomordentligt hedrad att i samband med Föreningens stora jubileum erhålla ett utmärkelsetecken, bärande en av dessa svenska forskares bild.

Det uppdrogs åt mig och sekreteraren att utreda frågan. Sekreteraren kommer att efter mitt anförande lämna närmare uppgifter om kostnaden m. m.

I förening med styrelsen ställer jag sålunda förslaget att till Föreningens 100-årsjubileum tvenne medaljer instiftas, Törnebohm-medaljen och De Geer-medaljen. Mera behövs ju icke nu, de närmare bestämmelserna få vidare utformas. Beträffande den ekonomiska sidan föreslår jag ett initiativ från föreningsledamöternas sida, nämligen att vid föreningens nachspiel efter december- och maj-mötena varje år en insamling göres för »Medaljfonden», att förvaltas av styrelsen. Jag föreställer mig att blott viss del av den ganska ansenliga erforderliga summan behöver tillskjutas från de enskilda föreningsmedlemmarna; för den större delen lära väl mecenater bland industrier och institutioner ej komma att saknas. Medaljerna skola givetvis vara av svenskt guld.

För ärendets vidare behandling föreslår jag att det bordlägges för fattande av beslut vid det kommande föreningsmötet i januari 1962.

Därefter höll ordföranden, professor Ivar Hessland, ett med talrika ljusbilder belyst föredrag med titeln: Några synpunkter på maringeologisk forskning.

I anledning av föredraget yttrade sig fru Ebba Hult-De Geer och hrr B. Asklund, F. Brotzen, A. Martinsson, O. Mellis, C. G. Wenner samt föredragshållaren.

Vid den efterföljande supén på restaurant Conti avtackades de avgående styrelseledamöterna hrr B. Asklund och O. Meier för ett mångårigt och fruktbärande arbete inom Geologiska Föreningen.

Geolognytt

Sveriges geologiska undersöknings publikationsnämnd har f. o. m. 1 jan. 1962 följande sammansättning:

Professor B. Asklund, ordf.,
Docent P. H. Lundegårdh, redaktör,
Statsgeolog F. Brotzen,
Docent J. Lundqvist, bitr. redaktör och sekr.

Det tekniska publikationsarbetet kommer att ledas av redaktören, medan kommittén i dess helhet skall granska de inlämnad arbetenas innehåll ur allmän och vetenskaplig synpunkt.

Universitetskanslern föreslår att en laboratorsbefattning i sedimentpetrografi inrättas vid Uppsala universitet från nästa budgetår. Till befattningens förste innehavare föreslås laboratorn vid Lantbrukshögskolan B. Collini. Enligt riksdagens beslut skall undervisningen för Lantbrukshögskolans studerande i vissa ämnen förläggas till Uppsala universitet.

Rättelse till häfte 3

Chemical investigation of upper Cambrian shales at Hynneberg, Närke

By

G. Assarsson and V. Grundulis

I tabell 2, s, 273 har genom tekniskt missöde en radrubrik fallit bort. Tabellen skall se ut som följer:

Table 2. Composition of the pure kerogen substance in weight per cent

Sample no.	C	H	S	O+N[1] (cal.)	Molar prop. C:H: (S+O+N)
4	75	7.0	0.5	17.5	1:1.12:0.18
5	76	6.5	0.3	17.2	1:1.02:0.17
6	74	7.0	0.3	15.7	1:1.13:0.16
7	77	7.5	0.2	15.3	1:1.17:0.15
8	78	7.0	0.3	14.7	1:1.08:0.14
9	77	7.5	0.4	15.1	1:1.17:0.15
10	77	7.5	0.9	14.6	1:1.17:0.15
11	78	7.5	0.4	14.1	1:1.15:0.11
12	76	7.0	0.1	16.9	1:1.10:0.17

[1] According to Holmberg (1930) the N/C weight ratio in the alum shale in the Yxhult quarry near Hynneberg is 0.019 (Kjeldahl method) or 0.021 (Dumas method). The average N content of the kerogen is 1.5 %.

Nyheter från Sveriges geologiska undersökning

Ser. Aa. GEOLOGISKA KARTBLAD I SKALAN 1 : 50 000 MED BESKRIVNINGAR

N:o 199 *Uppsala* av P. H. Lundegårdh och G. Lundqvist. With English summaries. 1956
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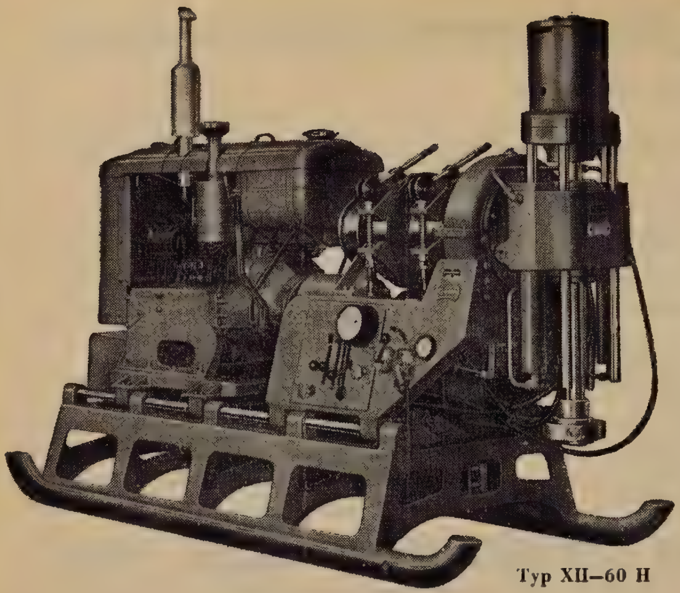

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